COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

ENGINEERING LIBRARY RR

OCT 12 1948

September, 1948

Photo by H. R. Tower

Early Developments in Pulverized Coal ▶

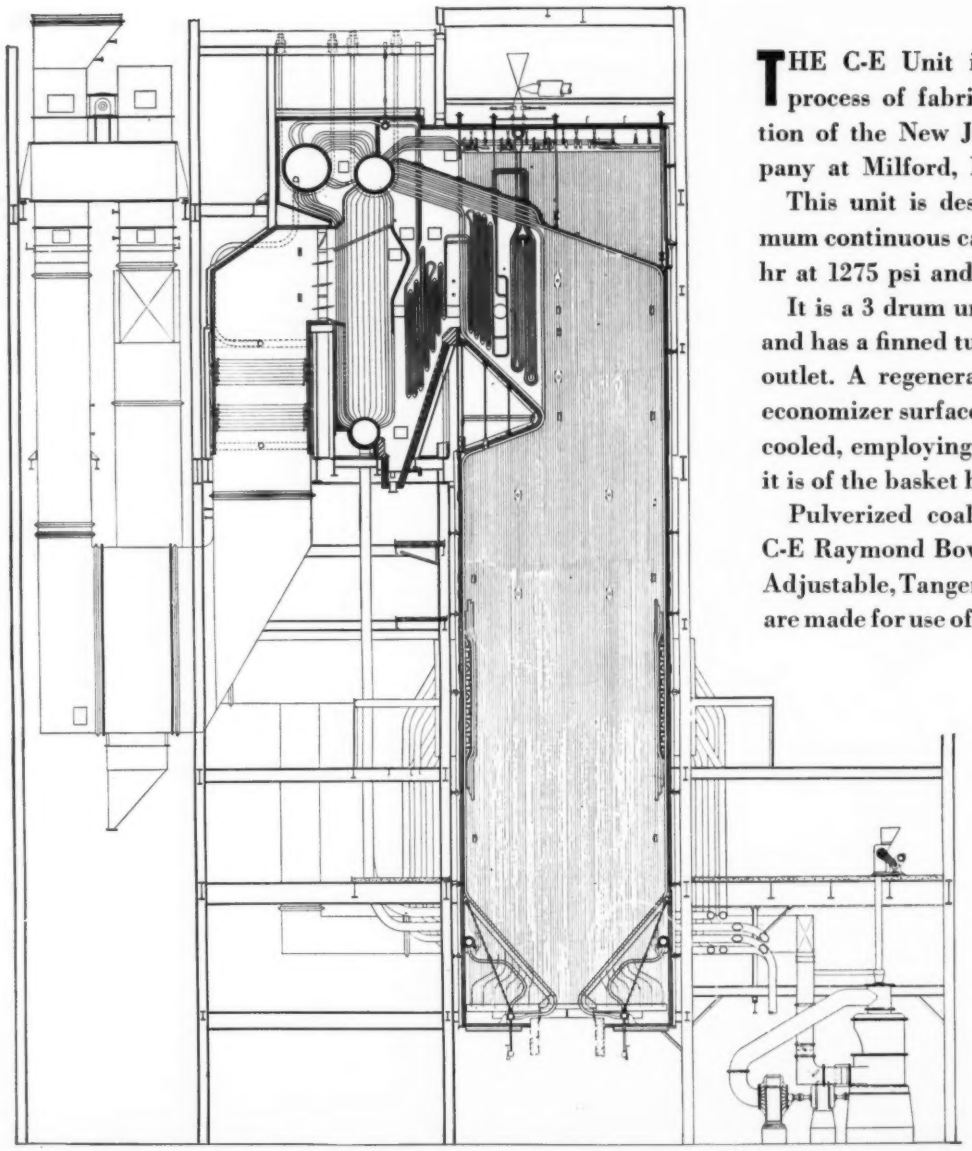
Comparison of Gas and Steam Turbines ▶

Some Recent Court Decisions ▶

Recent C-E Steam Generating Units for Utilities

GILBERT STATION

NEW JERSEY POWER & LIGHT COMPANY



THE C-E Unit illustrated here is now in process of fabrication for the Gilbert Station of the New Jersey Power & Light Company at Milford, New Jersey.

This unit is designed to produce at maximum continuous capacity 650,000 lb steam per hr at 1275 psi and 960 F.

It is a 3 drum unit with 3 stage superheater and has a finned tube economizer at the boiler outlet. A regenerative air heater follows the economizer surface. The furnace is fully water-cooled, employing closely spaced plain tubes; it is of the basket bottom type.

Pulverized coal firing is employed, using C-E Raymond Bowl Mills and C-E Vertically-Adjustable, Tangential Burners. Arrangements are made for use of oil fuel if and when required.

B-234

COMBUSTION ENGINEERING

200 MADISON AVENUE · NEW YORK 16, N. Y.

C-E PRODUCTS INCLUDE ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME TWENTY NUMBER THREE

CONTENTS

FOR SEPTEMBER 1948

FEATURE ARTICLES

Early Developments in Pulverized-Coal Firing—Part I ..... *by C. G. R. Humphreys* 34
A Comparison of Gas and Steam Turbines ..... *by Dr. O. A. F. Münzinger* 39
Experience with Burning Bagasse on Spreader-Type Stokers ..... *by H. G. Meissner* 44
Some Recent Court Decisions Affecting Owners and Operators of Steam Plants ..... *by Leo T. Parker* 47
Power Station Layouts 51

EDITORIALS

A Good Time for the Power Show 33
First Years Experience in Coal Nationalization 33
Activity in Natural Gas Distribution 33

DEPARTMENTS

New Catalogs and Bulletins 53
Review of New Books 57
Business Notes 57
Advertisers in This Issue 63

Combustion is indexed regularly by Engineering Index, Inc.

GERALD S. CARRICK, *General Representative* — ALFRED D. BLAKE, *Editor* — THOMAS E. HANLEY, *Circulation Manager*

Published monthly by COMBUSTION PUBLISHING COMPANY, INC., 200 Madison Ave., New York 16
A SUBSIDIARY OF COMBUSTION ENGINEERING COMPANY, INC.

Frederic A. Schaff, President; Charles McDonough, Vice-President; H. H. Berry, Secretary and Treasurer.

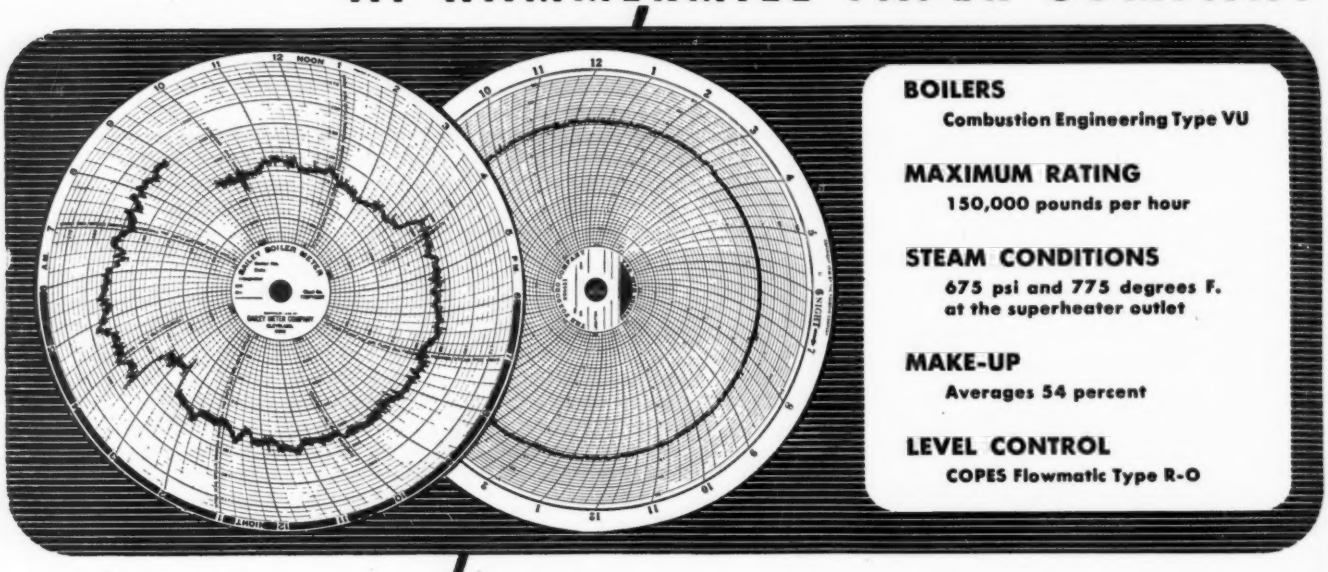
COMBUSTION is sent gratis to engineers in the U. S. A. in charge of steam plants from 500 rated boiler horsepower up and to consulting engineers in this field. To others the subscription rate, including postage, is $3 in the United States, $3.50 in Canada and Latin America and $4 in other countries. Single copies: 30 cents.
Copyright 1948 by Combustion Publishing Company, Inc.
Issued the middle of the month of publication.

Publication office, 200 Madison Ave., New York — Member of the Controlled Circulation Audit, Inc.

Printed in U. S. A.

FLOWMATICS

AT HAMMERMILL PAPER COMPANY



BOILERS
Combustion Engineering Type VU

MAXIMUM RATING
150,000 pounds per hour

STEAM CONDITIONS
675 psi and 775 degrees F. at the superheater outlet

MAKE-UP
Averages 54 percent

LEVEL CONTROL
COPES Flowmatic Type R-O

Hold BOILER WATER LEVEL WITHIN *Plus* OR *Minus* 1/2 INCH!

Except for momentary shrink and swell on sudden changes in boiler load, COPES Flowmatic is holding water level within plus-or-minus one-half inch on the two new Combustion Engineering Type VU Steam Generators at Hammermill Paper Company. Such close control is desirable for any fast-steaming boiler—especially if loads fluctuate rapidly or widely. You can be sure of this safe level control if you insist on the modern two-element COPES Flowmatic Regulator.

NORTHERN EQUIPMENT COMPANY
986 GROVE DRIVE, ERIE, PENNSYLVANIA
BRANCH PLANTS in Canada, England, France and Austria
Representatives Everywhere

Write for COPY
of Performance Bulletin 475

COPES

Headquarters for . . .

Boiler Feed Water Control . . . Excess or Constant Pressure Control, Steam or Water . . . Liquid Level Control . . . Balanced Valves . . . Desuperheaters . . . Boiler Steam Temperature Control . . . Hi-Low Water Alarms.

EDITORIAL

A Good Time for the Power Show

This is the year for the Power Show, officially designated as the National Exposition of Power and Mechanical Engineering. It will be the eighteenth time that this biennial show has been held concurrent with the Annual Meeting of the American Society of Mechanical Engineers. The date is November 29 to December 4, as usual, at the Grand Central Palace, New York.

With present power plant construction at an all-time peak and prospects of continued activity for several years to satisfy the ever-growing load demands, the time is propitious for such a show. This is further emphasized by the need to combat high fuel prices and other high operating costs through the employment of more efficient equipment as well as means for measuring and maintaining performance at a high level.

Presumably, physical limitations, as in the past, will preclude the showing of certain types of heavy equipment, but the many new developments and improvements in equipment of a size that can be exhibited should make this year's event especially profitable to those who are able to attend.

First Years Experience in Coal Nationalization

The report of the British National Coal Board, for 1947 issued the middle of July, covers the first full year of operation of the coal industry under public ownership. It contains some statistics and observations that should be enlightening to those individuals who would like to see similar measures adopted in this country.

From both the financial and the production standpoints, the year's results were disappointing. The monetary loss amounted to the equivalent of over 93 million dollars which, of course, will be passed along to the British taxpayer in one form or another. Some sixteen hundred labor disputes, exceeding by three hundred those of the previous year under private operation of the mines, accounted for a loss in production of more than 1,600,000 tons; and considerable absenteeism contributed further to rendering the total output short of the anticipated goal, although it exceeded that of the preceding year by about six million tons. Despite this, there was an increase of 26,000 in the number of persons employed, and instead of a reduction in the price of coal to the consumer there were two advances aggregating the equivalent of $1.30 per ton which is calculated to offset increased production costs during the present year; as indeed the first quarter of 1948 showed.

Commenting upon this situation, *Engineering* (London), while considering the personnel of the Coal Board to be competent, believes it to have been greatly handicapped by the administrative setup necessarily along civil service lines, with its extensive paper-work, and by the ponderous task of consolidating the numerous units of the industry. Moreover, it has been hinted that it may become necessary to force a further increase in the price of coal to the domestic consumer in order to subsidize a competitive export market.

The first year's experience under nationalization of the coal industry can hardly be taken as conclusive, but it did fall far short of the predictions of those responsible for bringing about the change; and it should serve as a warning to proceed slowly in other similar experiments in Britain and elsewhere.

Activity in Natural Gas Distribution

Judged by the large number of scheduled hearings before the Federal Power Commission on applications for authorization to increase natural gas pipe-line facilities, and the number of such lines and pumping stations already in service or under construction, it is apparent that this fuel is destined to play an ever-increasing role in our industrial activity.

Gas reserves greatly exceed those of oil and the larger part of these reserves are in Texas where heretofore much has been wasted by burning at the well-head. With adequate outlets, however, it should be profitable to put all the gas to use.

Although the quantity of natural gas burned under power boilers is a relatively small proportion of the total and in many cases, except in favored localities of the Southwest and Pacific Coast, is largely confined to off-peak or off-season periods for the pipe lines, the number of gas-burning boiler installations is nevertheless increasing. This may be attributed partly to higher coal and oil prices and partly to the fact that in some localities domestic and industrial demands have not yet absorbed all the available supply at the higher prices which such uses command. When they do, many gas-burning boiler plants will likely find it expedient to change over to pulverized coal, in anticipation of which most of these units have been designed for burning alternate fuels.

Furthermore, at such time as the present experimental processes for synthetic production of oil from natural gas become economically feasible on a large commercial scale, it is reasonable to expect that they will consume practically all excess gas at the source. This, added to the fact that the number of process uses for the gas is continually widening, strengthens some previous predictions that before long gas would become too valuable to be used as fuel under power boilers.

Early Developments in Pulverized-Coal Firing—Part I

By C. G. R. Humphreys

Research Dept., Combustion Engineering Co.

This is the first of three articles on pulverized coal developments prior to its establishment on a firm commercial basis for firing stationary boilers. It reviews a number of early attempts during the period from 1807 to 1913. A second article will carry on from 1913 through 1924 and a third will discuss applications in the marine and locomotive field.

SO MANY vain attempts to make and use powdered coal are found in records of the past 140 years that this writer found himself thinking ironically of the words of Shakespeare: "O brave new world that hath such people in't!"[1]

Too often the inventor published his ideas as if to say: "This is it, boys! The millenium has arrived." Then his forlorn hopes were followed by nothing more for a decade or two—a quiescent period before the next storm of ideas.

Our New World also had an interesting story of seemingly vain endeavors. Who is there now who knows what kinds of equipment, called Danks boilers, were successfully fired with pulverized coal in Chattanooga, back in 1870?

Gone are those central supply companies which were to provide our smaller needs as was stated so interestingly in 1924: "Coal can be delivered by rail or road truck wagon and run out into hoppers at the works, or, for smaller quantities, can be supplied as required in steel drums. In cases where the collective demand is for, say, a number of small industrial works grouped together, pulverized coal can be supplied through underground or overhead pipes by means of the air pressure or pumping systems, just as readily as gas, water or oil are supplied by means of pipes. In course of time, and when old prejudices have been overcome, the supply of pulverized coal to small consumers may become an important industry, and the saving in fuel resulting therefrom is certainly worthy of consideration."

Fig. 1 shows the Alonzo Kinyon small consumers unit which consisted of a 55-gal steel barrel, and held about 300 lb of pulverized coal. The barrel is shown in position to be swung up over the hopper for feeding coal to a burner unit with air supplied from a blower driven by a $^1/_4$- hp motor. This was one of many such devices now quite forgotten.

To the writer's knowledge, the earliest reference to pulverized fuel is found in a French patent dated 1807. This patent was for an internal-combustion engine designed to use powdered fuel.

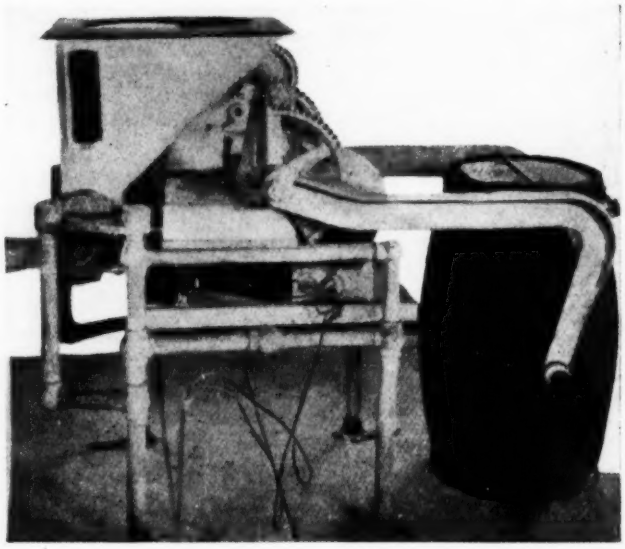
Since that time, and for about a century, many abortive schemes were proffered, as well as a few that possessed commendable qualities embodied even in present designs. Some individuals associated with this subject have also excelled in other diverse fields. For example, in 1818 the noted French scientist, Joseph Nicéphore Niepce, devised a "gasified" solid fuel burner using, if ever it were used, coal ground to dust. Niepce was better known, however, as an heliographer who made a photographic picture in 1822, or seventeen years before Daguerre perfected his famous daguerreotype.

In 1831, Henschel, a Westphalian, employed powdered coal to fire a brick oven in which he melted solder and tin.

Also, in 1831 J. S. Dawes secured an English patent on a device for delivering powdered coal and air to blast furnaces through tuyéres by artificial draft. The next patent noted by the writer was in 1846, by Desbois-sierres for a coal powdering system and blower. He ground charcoal in a stamp mill, sifted and fed it from a hopper into a pipe through which a fan blast of heated air carried the mixture to the firebox. The success of this method was mentioned, but we have found no definite idea as to the kind of unit it served.

From 1850 to 1860 considerable activity appeared in the German, French, and British iron and steel industries where powdered coal was gaining slight favor.

The French Mouchel, 1854, and the British R. Mushet, 1856, are names prominent in the steel industry at that time. Both men used methods somewhat like that of Dawes. Mushet's experiments used powdered charcoal and anthracite in his titanium steelworks.



(Courtesy of The Fuller Company)

Fig. 1—Suggested Kinyon pulverized coal equipment for small consumers, in position ready for lifting coal

[1] "The Tempest," Act V, Sc. I.

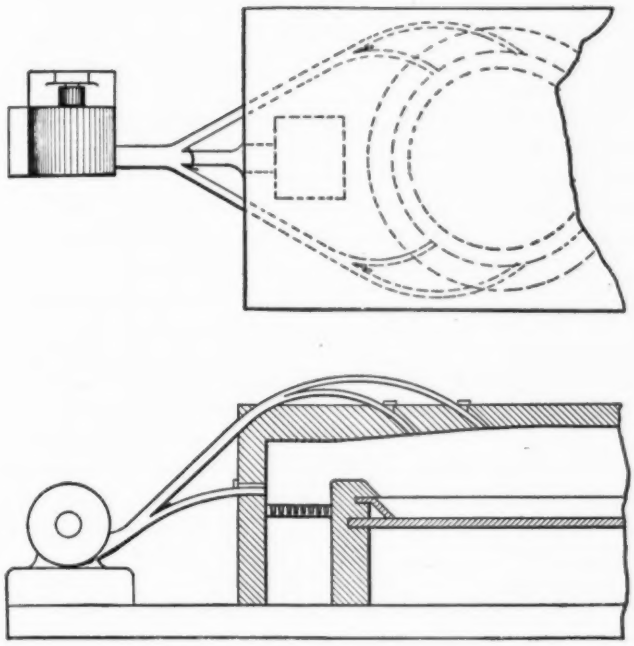


Fig. 2—Whelpley & Storer Apparatus
(Reproduced from "Powdered Coal as a Fuel," by Herington, 1920)

In the United States also, the finely ground coal was being referred to as "pulverized coal" to distinguish it from "dust fuel," or coarsely ground coal, sprayed or blown over beds of lump coal. The Whelpley and Storer patent of 1866 is one of the first U. S. patents for the application of powdered coal. The device somewhat resembled the Dawes apparatus of 1831. The inventors asserted that combustion of lump coal in the usual manner was very imperfect for want of a sufficiently intimate mixture with oxygen of the air. Therefore, they contended a large portion of the combustion gases escaped from the chimney as hydrocarbons and carbonic oxide. They proposed an improved coal-burning system as follows: "First to burn lump coal—as small a quantity as can be kept incandescent with blast supplied beneath the grate—then as large a quantity as possible of finely powdered coal blown in as a cloud with air supplied over the grate."

In 1868–1869 a series of careful tests was conducted in South Boston by Chief Engineer B. F. Isherwood, U.S.N. These tests were with the Whelpley and Storer System, Fig. 2, serving a horizontal fire-tube boiler fired by anthracite and bituminous coals. The powdered coals were blown onto a bed of incandescent lump coal and performances with lump coal were compared with lump and powdered coals together. The results did not approach expectations and indicated that burning lumps alone was preferable. The results in Table 1 are taken from the test data

TABLE 1—RESULTS OF TESTS WITH WHELPLEY AND STORER SYSTEM

Pounds of Water Evaporated from Water at 100 F per Pound of Coal

Anthracite		Semi-bituminous Coal	
Lump Only	Lump and Powdered Coal	Lump Only	Lump and Powdered Coal
6.65	5.60	7.56	8.46

Conclusions were that milling costs with the steam-driven pulverizers were excessive; anthracite could not be readily burned as in powdered form; and that air and dust leaks were hard to control.

The pulverizer consisted of a box having two chambers separated by a diaphragm and containing a single shaft with paddles. It was, in effect, a combined blower and pulverizer. Coal crushed to the consistency of coarse gravel was fed in, caught by revolving paddles and reduced to a powder, particle sizes being about 200 mesh maximum. Table 2 is taken from a report of the mill performance.

Lieut. C. E. Dutton, U. S. Ordnance Corps, reported as follows on his visit to the Boston installation: "Their method consists of pulverizing the coal and blowing it into the combustion chamber where it is ignited and burned in the air which floats it."

TABLE 2—WHELPLEY AND STORER MILL

Paddle diam, in.	18	42
Rpm	2100–2200	
Hp required	3½	15
Bituminous coal ground per unit of time, lb	300	2000
Anthracite coal ground per unit of time, lb	200	1000–1200

In England, in 1868, T. R. Crampton was operating his works with powdered coal in steel furnaces and in boilers at Woolwich Arsenal. His grinding device was unique in that it used flour millstones of best Derbyshire gritstone to render the coal reasonably fine. Crampton wrote: "It is essential that the size of the coal should be determined, and that it should, during its flotation through the furnace, be so conducted that any overcharged and undercharged currents of air and coal should be continually re-intermixed until the whole of the carbon is consumed; otherwise there would be deposits of coal on one part of the furnace and free oxygen on the other."

He had found that even if a well mixed current of coal and air entered a pipe they would tend to separate during passage to the furnace. Fig. 3 shows his method where fuel and air strike downwards, impinge and re-admix to pass on over the bridge to the heating chamber.

His next and most noteworthy experiments were with revolving puddling furnaces of which Fig. 4 was his final

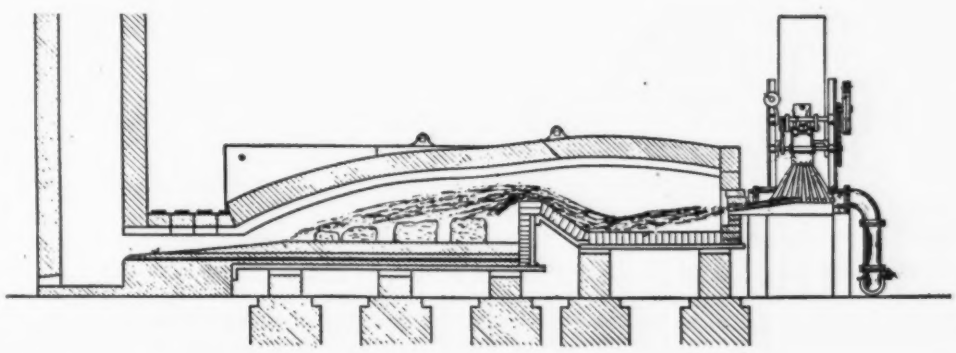


Fig. 3—Crampton powdered coal furnace
(From Iron & Steel Institute Journal, 1873)

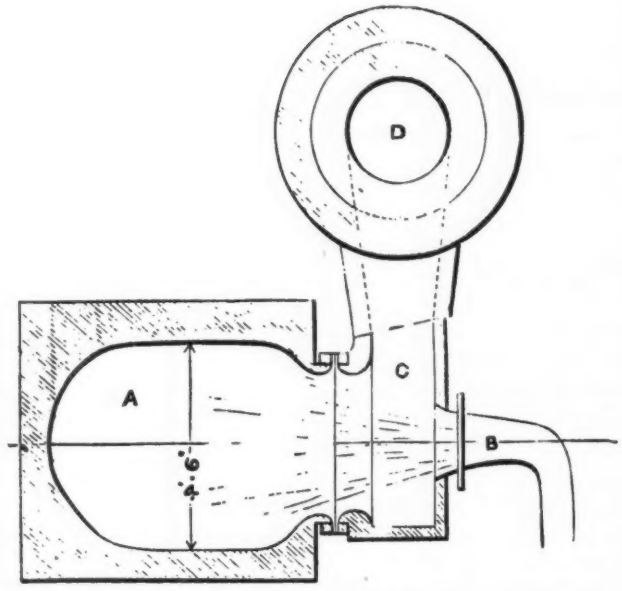


Fig. 4—Crampton's revolving puddling furnace, using powdered coal
(From Iron & Steel Institute Journal, 1873)

design. This was a furnace 4 ft 6 in. diam made to turn at 15 rpm. Coal and air were delivered through *B*, across the flue *C*, into the puddling chamber *A* where combustion was completed, and the combustion products were discharged to the chimney at *D*. The rotary furnace was cooled externally by a special water jacket. It was concluded from tests and practical applications that the furnace was economical and produced 5 long tons of puddled bloom each 12-hr shift for a coal consumption of 10 cwt per ton. Iron produced was claimed to be superior to that normally available. Several of Crampton's equipments were used in England and on the Continent. He also experimented with powdered coal in a marine boiler of 1500 sq ft heating surface. Fire bars were removed and the furnace was lined with bricks. Coal and air combined were injected into the furnace, and 10 to 11 lb of steam were generated per pound of coal burned. "It is impossible," said Crampton, "to produce smoke, as the whole of the volatile matter is produced in the first instance. The consequence is that the uptake of the boilers can have no flame in them."

One discussor of Crampton's paper before the British Iron and Steel Institute, in 1873, stated that he had been in the States, where he had seen the application of that plan with a slightly different mode of crushing the material in the shape of what was called a pulverizer.

In the next score of years a great many new ideas were introduced and among them several German devices which became popular for a time among the comparatively few users of this type of coal firing. Fig. 5 shows two of several schemes, described by Bryan Donkin in 1895 as being established practice. These were the Wegener and the Schwartzkopff systems.

Donkin was noted for several engineering innovations at this time. It may surprise some readers to know that he introduced into this country the now well-known Ringelmann Chart which is only a more convenient form of the smoke chart once bearing his name.

Donkin in *Engineering*, London, Sept. 20, 1895, described work he performed with Lancashire boilers using the German Wegener System, as follows: "The powdered coal gradually falls out of the sacks, as required, into the hopper, and then on to a sieve about $5^1/_2$ in. in diameter, with small openings in it. The powdered coal would not go through this sieve with certainty without continual tapping, and this is done in the following way: Immediately beneath the hopper, and level with the boiler-house floor, is an air-pipe about 20 in. diameter, through which nearly all the air for combustion is admitted. As it enters, it is made to pass through the blades of an air-wheel or turbine, and this passage of the air causes the latter to revolve. On the axis of this air-wheel is a little knocker, which taps the sieve from 150 to 250 times per minute, causing the powdered coal to descend vertically through the sieve, meeting the air for combustion as it ascends vertically. In this way the powdered coal and air for proper combustion get thoroughly mixed and pass on into the boiler flue, each particle of coal being surrounded by air. The stoking simply consists of putting the sacks of powdered coal, from time to time, into the top of the hopper, and seeing that the right amount of air is entering for combustion. If there be not sufficient

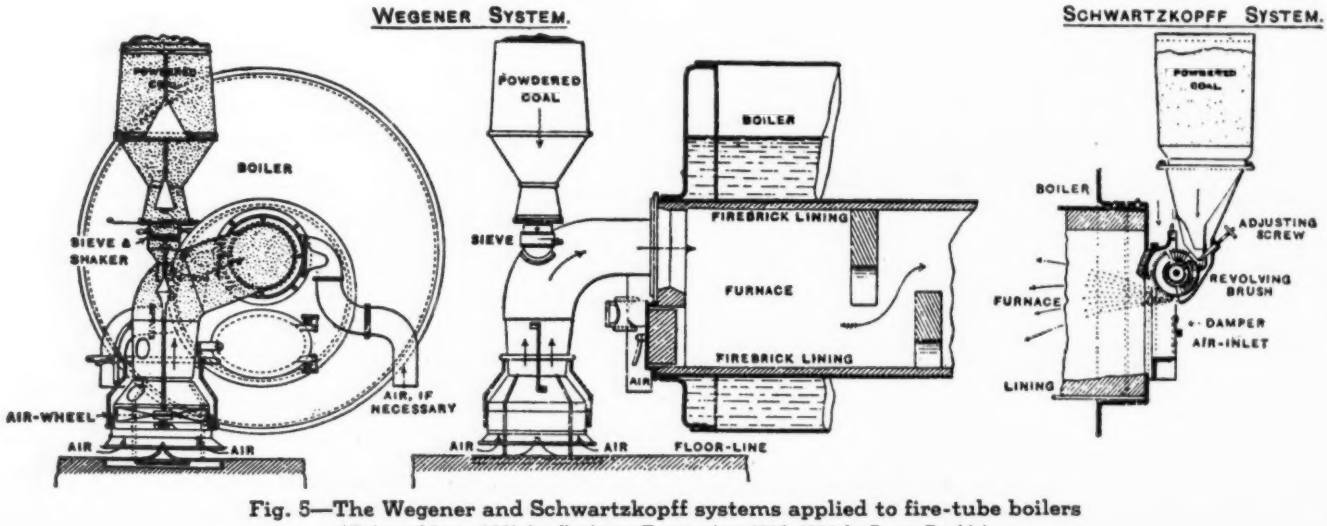


Fig. 5—The Wegener and Schwartzkopff systems applied to fire-tube boilers
(Federated Inst. of Mining Engineers Transactions 1895–1896, by Bryan Donkin)

air for proper combustion entering through the main opening, as indicated by a little smoke, there are two other smaller pipes where additional air can be admitted, each kind of coal requiring a somewhat different amount.

"The only object of the air-wheel revolving, from 50 to 80 rpm, is to shake the sieve and cause the powdered fuel to go into the furnace in the quantity desired. When more steam is required a greater knock is given to the sieve, and more powdered coal is burned; when less is needed a lesser shake is necessary. An adjustment is provided to regulate the amount of coal entering, which is done by turning with two fingers the $^1/_2$-in. screw. The duty of the attendant is to put the sacks of powdered coal into the hopper, and he ascends a short ladder to do this, or a conveyor can be used. One man can, therefore, attend to several boilers. The ignition of the powdered coal seems to take place immediately on its arrival in the hot firebrick chamber, and about 1 ft. from the boiler front."

In *The Engineer*, London, May 15, 1896, Donkin published the results of two tests with and without Wegener apparatus which are summarized in Table 3.

TABLE 3—TEST WITH AND WITHOUT WEGENER SYSTEM

	Without Wegener Apparatus	With Wegener Apparatus
Total coal burned	1600	1415
Coal burned per hour	225	211½
Moisture in coal, per cent	9	1.2
Ashes	About the same	
Temperature of feedwater entering the boilers, F	63.0	48.2
Pounds of water evaporated per pound of wet coal	4.95	7.46
Same calculated from and at 212 F	5.90	9.00
Water evaporated per pound of dry coal with feedwater at 212	6.48	9.11
Thermal efficiency of boiler	54	71
Temperature of gases at the base of chimney, F	438	412

Prior to 1894, an important year in this survey, oil was employed as fuel in the portland cement industry for spraying into the ends of the furnaces, or kilns, by means of steam or air jets. This method was completely satisfactory until oil costs increased considerably. As a result of this situation, in that year the Atlas Portland Cement Company began experiments, which by 1897 established the successful application of pulverized coal to the cement industry in America. Abroad, the change was not then found acceptable, but here, the new fuel soon found a firm niche and its rapid progress in this and other industries was certain. The Atlas experiments were in charge of Messrs. Hurry and Seaman, and to them belong much of the credit for these successes.

TABLE 4—THREE TESTS OF NO. 2 SIZE BETTINGTON BOILER (WITHOUT ECONOMIZERS)

	Low Rate	50% Overload	100% Overload
Coal used	Broomhill slack	Griff slack	Broomhill slack
Coal feed, lb per hr	897	2,078	2,733
Cold water evaporation, lb per hr	6,829	11,790	17,307
Feed temperature, F	60	50	64
Pressure, psi abs	165	166	165
Steam temperature, F	496	561	534
Outlet gas temperature, F	580	698	750
Superheated steam, from and at 212 F, lb. per hr	8,714	15,621	22,374
Water evaporated per lb coal, from and at 212 F, lb	9.71	7.55	8.18
Boiler horsepower developed	253	454	650
CO_2, per cent	12.5	12.83	17.5
Analysis of dry coal			
Ash, per cent	14.33	16.2	14.33
Volatile, per cent	32.55	16.57	32.55
Sulphur, per cent	0.99	0.93	0.99
Fixed carbon, per cent	52.13	66.3	52.13
Moisture in coal as fired, per cent	3.85	14.39	3.85
Net Btu per lb	11,870	9,648	11,870
Boiler efficiency, per cent	79	75.6	66

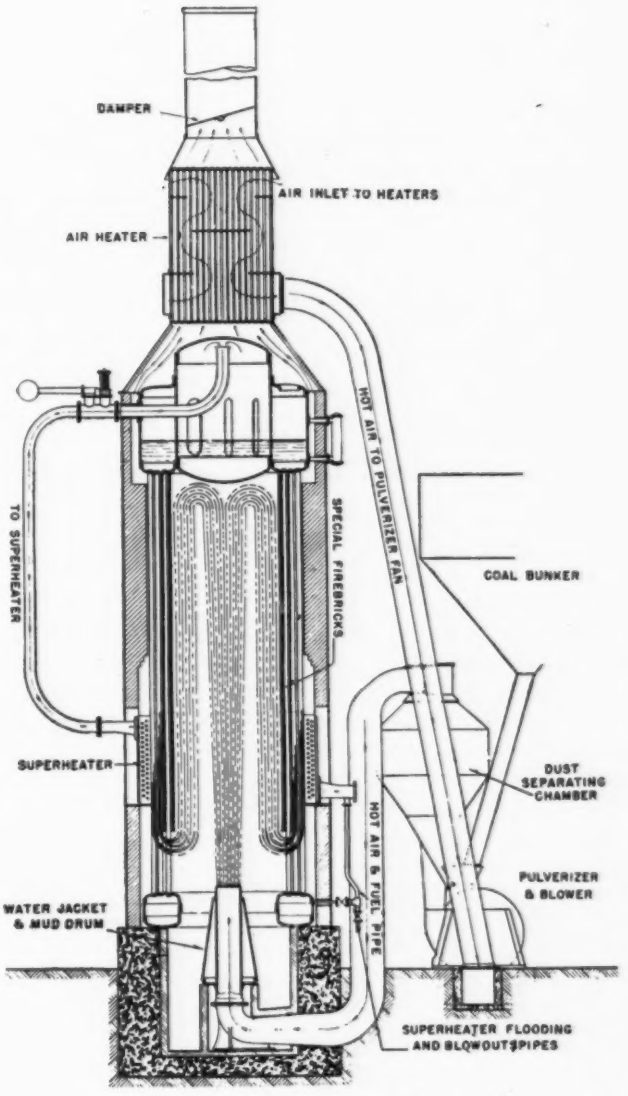


Fig. 6—Bettington boiler
(Courtesy of Frazer & Chalmers, Ltd).

In 1905, the British Commission on Coal Supplies reported a dismal summary of pulverized coal usage which must have been aimed at the industry outside of the cement workings of U.S.A. It stated in part:

"For many years a large amount of experimenting has been done with a view to the discovery of some process for burning fuel in the form of an impalpable powder, the idea being to feed the furnace with a blast of air and fine powder which will burn like sprayed oil or a gas jet. We have it in evidence that such powders have been worked successfully in experimental plant but, so far as we know, there are no installations at present in operation in this country at which such powdered fuel is used commercially and successfully."

It was in 1905 also, after extensive tests in the Transvaal, that C. A. Bettington's successful pulverized-coal-fired boiler was exploited. First patents were awarded in America, but most of the units seem to have been erected elsewhere. The Bettington boiler, Fig. 6, consisted of top and bottom headers connected by symmetrically spaced vertical tubes. Coal firing was vertically upwards in a firebrick-lined combustion chamber. The high furnace temperatures fused the ashes which fell into

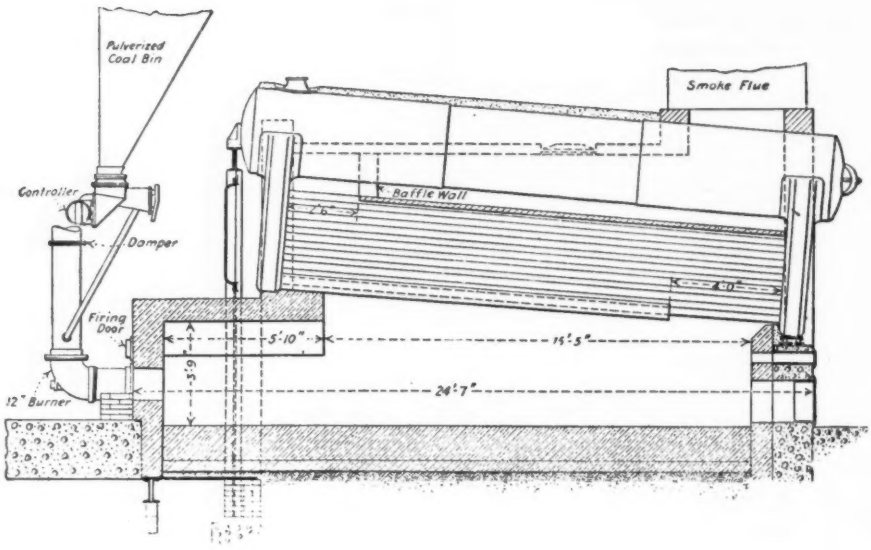


Fig. 7—Franklin boiler as originally arranged for burning pulverized coal
(Bulletin of Canadian Department of Mines, by John Blizard)

a pit in small granular solid pieces. These units were described as self-cleaning by slag formation near the top, and quenching of falling slag at the bottom header. Several sizes were built up to 40,000 lb of steam per hour at steam pressures up to 500 psi. Published unit efficiencies reached 82.6 per cent. Table 4 summarizes three tests on the type of boiler shown in Fig. 6.

Pulverized coal burners have also undergone a number of progressive developments. The first burners were made up of nozzles fitted into the coal pipes, and firing was horizontal as in metallurgical furnaces, Scotch and other fire-tube boilers.

Fig. 7 shows a 300-hp Franklin boiler of Heine type, equipped to burn pulverized coal in 1913. In line with general practice of that period the furnace was inadequate for stoker firing and more so for pulverized-coal firing, with the boiler set so low that the distance from the grate to the heating surface was but a few feet. This resulted in abnormally high furnace heat release with its attendant troubles.

This setting proved unsuccessful when its three burners did not permit operation at full rating, and its vertical walls and brick arches failed completely. Hard slag and unburned fuel accumulated rapidly and blocked the furnace bottom, gas passes and tubes. Consequently, in March 1915 the furnace was enlarged, as shown in Fig. 8, by digging a conical pit and resetting the burners, after which it is reported to have operated satisfactorily with a protective coating of one to three inches of slag maintained on its walls.

A later writer, Leonard C. Harvey, in 1924 summarized reasons for the early failures with powdered coal as follows:

"The numerous failures which attended the early history of fuel applied in pulverized form have earned for the subject some contempt and ridicule in engineering circles. The heavy deterioration of refractory linings; the rapid coating of boiler surfaces with an impervious insulating layer of ash slag; irregularity of fuel control; the constant fear either of spontaneous combustion or explosion, both of which frequently occurred in these early experiments, all combined to ensure failure.

"In the past, the fuel was ground or disintegrated by machinery which produced what we may now term *lump* dust, not always sufficiently dry, and this was fed into an air blast by means of rotary brushes, disk or table feeders, or blown at high velocity into a combustion chamber by compressed air; and the combustion chamber itself was totally inadequate in area to ensure combustion before the gases reached the boiler heating surfaces."

In concluding this cursory survey of early developments in pulverized-coal firing it may be in order to digress by noting that the well-known European fuels authority, Dr. P. O. Rosin, speaking before the Institute of Fuels Conference on Pulverized Fuel at Harrogate, England, in 1947 extolled Claude Bettington as "the first to visualize that pulverized fuel firing demanded a radically new conception of boiler and furnace design." Also, he spoke of the late John Anderson of Milwaukee as one "without whom the development of pulverized-fuel firing for steam boilers might have been very much slower and less successful." Anderson's work, also those of some other contemporaries in the very active period from 1913 to 1919, will be considered in a second installment of this article. Also, marine and locomotive applications and a bibliography will follow in a concluding article.

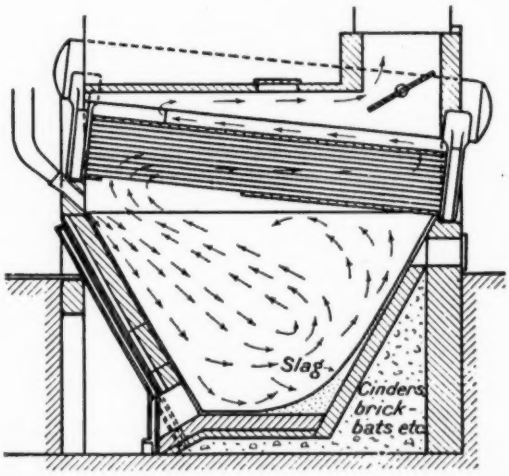


Fig. 8—Setting of Franklin boiler as altered
(Bulletin of Canadian Department of Mines, by John Blizard)

A Comparison of Gas and Steam Turbines

By Dr. O. A. F. MÜNZINGER, Cons. Engr., Berlin

From this analysis the author concludes that there is little prospect of the gas turbine being able to compete with the steam turbines in large sizes; that the single-stage open-cycle gas turbines with heat-exchangers, in capacities up to around 6000 kw, are competitive with steam turbines, both because of efficiency and simplicity; and that an efficiency of over 30 per cent is attainable with a two-stage closed-cycle gas turbine operating with an inlet temperature of 1300 F. As it becomes feasible to increase the inlet temperature, the efficiency will improve. Special applications of the gas turbine are also discussed.

WITH the introduction of almost every important new heat engine the decisive factors for technical and commercial success have usually been more or less obscured by theoretical considerations which, though not always secondary, have often proved of less importance in competition with other types of heat engine. Reliability, simplicity and low first cost are usually of equal or greater significance than low heat consumption. Engineers who fail to recognize this will almost invariably lose out in the long run. Therefore, it is the author's intention here to examine the following fundamental questions as simply as possible and without recourse to intricate theoretical computations:

1. Is there any chance of further materially reducing the heat consumption of steam-turbine plants below present values and to what extent?
2. Will gas turbines in the near future show a lower heat consumption than steam-turbine plants?
3. Will gas-turbine plants be substantially simpler or cheaper in first cost than steam-turbine stations?
4. Is it likely that the gas turbine will in the not too distant future supplant the steam turbine to a considerable degree for stationary service?

A number of large power stations are now employing boiler pressures around or approaching 1800 psi and total steam temperatures of 930 to 985 F, with reheat of 750 to 800 F. Under these steam conditions the heat consumption, at favorable load and with good coal and cooling water, figures about 11,900 Btu per net kilowatthour.[1]

[1] Dr. Münzinger is apparently basing this on European practice and conditions, as this performance has been exceeded in a number of American power stations. For instance, Port Washington Station, Milwaukee, has long operated at a net station heat rate of 10,400 to 10,600 Btu per kwhr, and the new Philip Sporn Station, designed for 2000 psi and 1050F reheat, is calculated to attain 9270 Btu per kwhr. Some other installations now under construction or on order, with reheat, are expected to reach well under 10,000 Btu per kwhr. —Editor.

By increasing the live steam and reheat steam temperatures to around 1100 F with boiler pressures ranging from 1800 to 2800 psi, a reduction up to ten per cent in station heat rate per kilowatthour can be attained, and in another decade a further reduction of perhaps four per cent will likely be possible. There is a large thermal saving through raising the steam temperatures from 930 F initial and 800 F reheat to 1100 F for both initial and reheat. It is safe to assume that such difficulties as may be encountered in going to this higher temperature will be no greater than those which were successfully overcome twenty-five years ago when higher pressures were first adopted.

This can be taken as an answer to Question 1.

Open-Cycle Gas Turbines

Two systems of gas turbines are in practical use today, namely, the open and the closed cycles. With the former the products of combustion pass through the turbine, and with the latter compressed air is heated by the combustion products and then passes to the turbine. In other words, with the open cycle fresh gases are constantly expanding through the turbine whereas with the closed cycle the same air is expanded and compressed repeatedly.

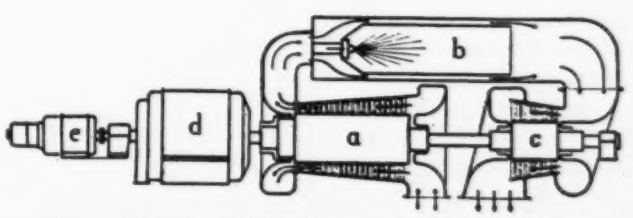


Fig. 1—Diagram of simple open-cycle gas turbine

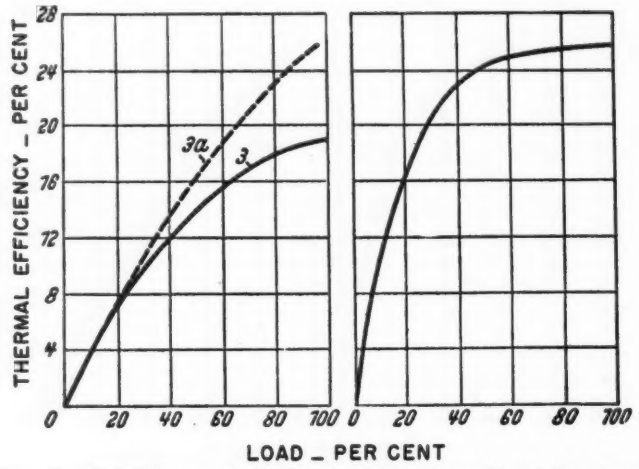


Fig. 2—(left) Thermal efficiencies of open-cycle, single-stage gas turbine with (3) and without (3a) heat-exchangers
Fig. 3—(right) Curve showing improved efficiency with separately driven compressor at variable speed

Fig. 1 represents the simplest form of open-cycle gas turbine. Here the compressor *a* is driven by the gas turbine *c* and supplies air at 40 to 70 psi to the combustion chamber *b* where the fuel is burned and the gases pass to the turbine at 1100 to 1300 F (with 12 to 16 per cent excess air). After expanding through the turbine they exhaust to the atmosphere. The difference between the power output of the turbine and that required to drive the compressor is the net output and amounts to about one-third of the total. Such units are simple and do not take up much space; but, due to the heat lost with the exhaust gases, they have only a moderate efficiency of 15 to 19 per cent which also decreases rapidly with decreasing load. This characteristic is shown by the solid curve in Fig. 2.

If a higher efficiency is desired, the compressed air must be heated in a heat-exchanger by the exhaust gases from the turbine and the compressor must be driven by its own gas turbine at variable speed. Generally speaking, the larger the heat-exchanger the higher the thermal efficiency. Under ordinary conditions, the heat-exchanger surface amounts to from $8^1/_2$ to 16 sq ft per net kilowatt. The broken curve in Fig. 2 represents the efficiency with a heat-exchanger as compared with that without a heat-exchanger as shown by the solid curve.

Improvement of efficiency with separate drive for the compressor is shown by comparison of Figs. 2 and 3. With fluid fuels, separately driven air compressors and large heat-exchangers, thermal efficiencies of 26 to 29 per cent and net outputs up to 6000 kw are attainable with the open cycle.

Still higher net outputs are possible with two-stage gas turbines and two combustion chambers, as indicated in Fig. 4. With such an arrangement the first combustion takes place in chamber *g* under pressure of 200 to 350 psi and the second combustion in chamber *i* after the gases have expanded in turbine *h* to between 40 and 70 psi. Such arrangements, which involve some complications, require heat-exchangers having a surface of only 4 to 8 sq ft per kilowatt. With an initial temperature of about 1100 to 1200 F thermal efficiency ranges from 31 to 33 per cent.

In contrast to open-cycle gas turbines which exhaust to the atmosphere, the lower pressure level of the closed-cycle gas turbines at full load is about 140 psi. Referring to the schematic diagram, Fig. 5, the compressed air leaves the air heater *i*, which can be fired with any kind of fuel, at a temperature of around 1200 F. After expansion in the gas turbine *c* it is employed for heating the air leaving the three-stage compressor in heat-exchanger *g*. The upper pressure level is about 425 psi. Dust, soot and tar vapors cannot foul closed-cycle turbines, and the various components are smaller and lighter than with the open cycle. The thermal efficiency, even at partial load, is good, as indicated in Fig. 6 where curve *a* includes auxiliaries and curve *b* is exclusive of auxiliaries. It will be noted that the drop with the falling load is even less than for steam turbines.

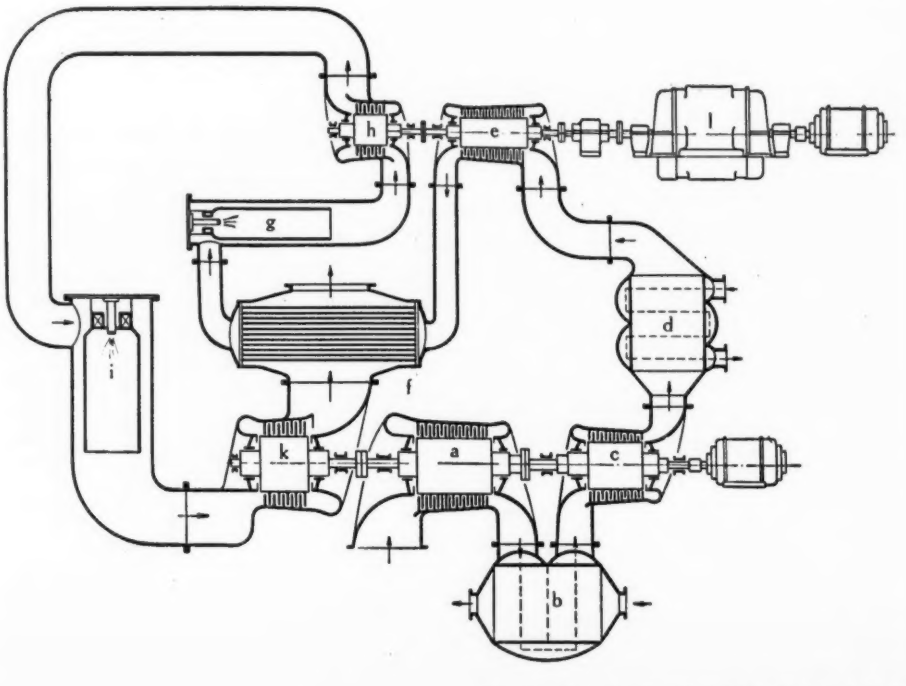


Fig. 4—Sketch of two-stage, open-cycle gas turbine

a is first compressor stage; *b*, air cooler; *c*, second compressor stage; *d*, cooler; *e*, third compressor stage; *f*, heat-exchanger; *g*, first combustion chamber; *h*, high-pressure turbine; *i*, second combustion chamber; and *k*, low-pressure turbine.

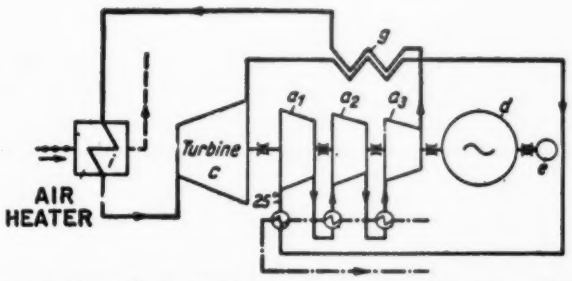


Fig. 5—Sketch of single-stage, closed-cycle gas turbine

a_1 to a_3, three compression stages; *c*, gas turbine; *d*, generator; *e*, starting motor; *g*, heat-exchanger; and *i*, air heater.

Regulation

Regulation of closed-cycle gas turbines deviates from that of open-cycle turbines and from steam turbines. It is accomplished by adding to or subtracting compressed air from the system. In this way the weight of circulating air, which is proportional to the output of the turbine, is increased or decreased. Large changes in load can be obtained in very short time and with only slight change in the turbine speed. In fact, tests on a 2000-kw machine showed that by raising the inlet pressure of the compressed air from 140 to 240 psi the output was increased from 550 to 1250 kw in 13 sec. The load was decreased from 1250 to 650 kw in 8 sec. During this time the speed varied by less than one per cent.

Thermal Efficiencies Compared

Air heaters for closed-cycle gas turbines can be so built that their tube temperature will not exceed that of the hottest turbine blades by more than about 180 deg F. The maximum stress on the hottest heater tubes ranges from 2100 to 2800 psi and that of the hottest turbine blades from 8500 to 12,000 psi. Notwithstanding the decrease in tensile strength of alloy steels when exposed for a long time to temperatures in excess of 1100 or 1200 F, the small value permissible for the heater tubes is not attained until a temperature is reached of 225 to 352 deg F in excess of that permissible with the turbine blades.

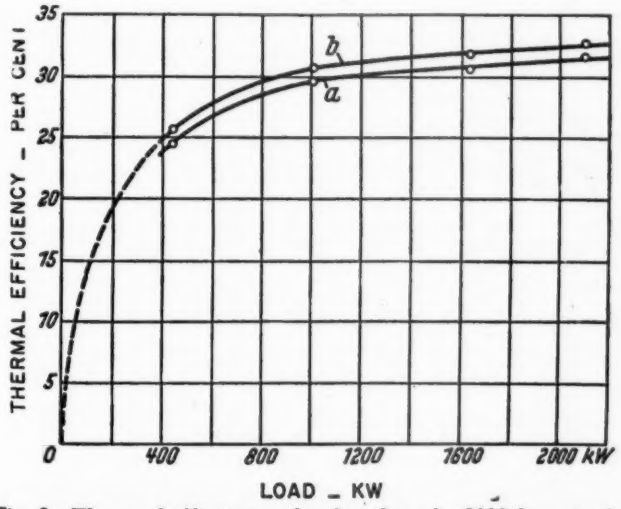


Fig. 6—Thermal efficiency of a closed-cycle, 2000-kw, single-stage gas turbine

Curve *a* represents efficiency inclusive of auxiliary power; and curve *b* efficiency exclusive of auxiliary power.

When considering the thermal and financial economies of a given gas turbine, its first cost must be carefully taken into account because the cost of a large heat-exchanger can greatly influence the decision. Another factor to be considered is the cost of fuel delivered to the site.

Fig. 7 shows the calculated thermal efficiencies of steam turbines and gas turbines of both the open- and closed-cycle types, for various initial temperatures of the gas or air. The scale at the left applies to steam turbines and gas turbines operating with coal as fuel, whereas that at the right applies to open-cycle gas turbines employing liquid fuel. The lower efficiency with coal is based on the condition that the coal must first be gasified in a producer.

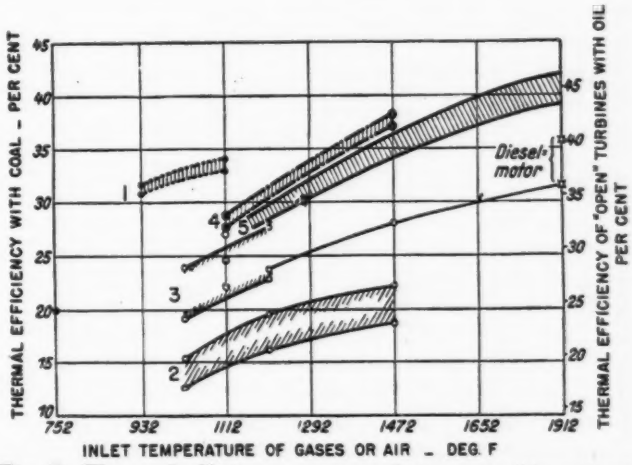


Fig. 7—Thermal efficiency ranges of steam-turbine plants and gas turbines compared, at most favorable loads and various inlet temperatures of working medium, with both producer gas from coal and with oil as fuel

Curve *1*, 50,000-kw steam turbines, 1700–2000 psi, 930–1100 F initial and reheat; curve *2*, single-stage, open-cycle gas turbine without heat-exchanger (mechanical efficiency of turbine and compressor = 70 per cent); curve *3*, single-stage, open-cycle, 2000-kw gas turbine (mechanical efficiency of turbine and compressor combined = 75 per cent) with heat-exchanger; curve *4*, 15,000-kw, two-stage, closed-cycle gas turbine; curve *5*, two-stage, closed-cycle gas turbine.

With coal as fuel and an inlet gas temperature of around 1100 F, a thermal efficiency of only about 18 per cent is attainable with the open-cycle gas turbine without heat-exchangers, assuming a combined mechanical efficiency of the compressor and its driving turbine of 75 per cent. However, with heat-exchangers and inlet gas temperatures of 1100 F and 1472 F, the respective thermal efficiencies are 22 and 27.5 per cent.

The thermal efficiency attainable with coal-fired, open-cycle gas turbines is therefore considerably less than that of large steam turbine units employing initial and reheat steam temperatures around 1100 F where efficiencies of 32 and 34 per cent are to be reached. In other words, it may be stated that coal-fired, open-cycle gas turbines cannot compete with large steam-turbine plants, if inlet-gas temperature of 1450 F is not permissible, the combined mechanical efficiency of the compressor and its turbine is less than 80 per cent, and as long as the gas turbine cannot be operated on pulverized coal direct.

With a coal-fired, two-stage, closed-cycle, gas-turbine plant a thermal efficiency of 30 per cent is readily attainable with an inlet temperature of 1300 F. Professor Quiby of the Swiss Federal Technical High School in

Zürich has conducted tests with an oil-fired, closed-cycle gas turbine of 2000 kw net output and at an inlet temperature of 1300 F. He attained a thermal efficiency of 30.5 at full load, including the power consumption of the auxiliaries.

It follows that the answer to the second question raised at the beginning of this article is: With coal as fuel, an open-cycle gas turbine can compete with steam turbines only if it is built for an inlet temperature of around 1450 F. On the other hand, there seems to be an excellent chance of improving one-stage, closed-cycle gas turbines so that their heat consumption at 1300 F inlet temperature will be about the same as that of a large steam turbine station employing around 1100 F initial and reheat temperature.

Open-cycle gas turbines are superior to closed-cycle gas turbines in so far as they fundamentally admit of the use of higher inlet temperatures. But they must compensate for the losses in the gas producer, in order to attain a performance comparable with closed-cycle turbines working with 1300 F inlet temperatures. For open-cycle turbines with inlet temperatures much in excess of 1300 F one must resort to ceramic materials and to water cooling of the blades. If evaporated water is not employed for this purpose, the small passages in the blades may become choked with scale.

Many engineers are in the habit of comparing the performance of gas turbines with that of very large steam turbine installations, and in so doing disregard the fact that the heat consumption of steam turbines rapidly increases with decreasing size. Only very large condensing steam plants attain a thermal efficiency of 30 per cent or higher, whereas gas turbines have thus far shown their lowest heat consumption in sizes of 6000 to 8000 kw, which is decreased only 4 to 8 per cent for units of 2000 to 3000 kw. Therefore, it follows that gas turbines are able to raise the thermal economy of small power plants to values at present unattainable with steam turbines.

Special Applications

Locomotives offer an attractive field for gas turbines due to their higher efficiency (21 per cent compared with 10 or 12 per cent for steam drive), their small consumption of lubricants, smooth running, short time required for starting, independence of water, freedom from freezing, and less weight.

For standby service, where simplicity, relatively low first cost, small space requirements and quick starting are more important than low heat consumption, the open-cycle, oil-fired gas turbine of simple design is well adapted.

Other advantageous applications are in connection with oil refineries employing the Houdry Process, blast furnaces and certain chemical plants; also for driving diesel-engine superchargers to boost capacity.

In answer to the third and fourth questions it may be stated that with liquid and gaseous fuels gas-turbine plants are simpler than steam-turbine plants. The field best suited to gas turbines is in the capacity range from 2000 kw to 15,000 kw. With coal as fuel large power plants will for a long time continue to be the domain of the steam turbine. Open-cycle gas turbines have much to offer for standby or emergency service; and there are wide opportunities for them in the locomotive and oil-refinery fields.

Hi-Pressure Gage Glasses

Round, Tubular and Flat Type

RUBBER GAGE GLASS GASKETS
Series 750 . . . All Sizes

Fig. 21 Fig. 22

Other Ernst Specialties are given in Catalog No. 48 P

GAGE GLASS ILLUMINATORS
NEW PLASTIC GUARDS
SIGHT FLOW INDICATORS
SPLIT-GLAND WATER GAGE
STEEL GAGE VALVES
FLAT GLASS INSERTS
ALL IRON GAGES
HIGH & LOW ALARM COLUMNS
MICA SHIELDS AND GASKETS
AND OTHER HELPFUL TIPS ON BOILER ROOM SAFETY

Inclined for Better Visibility
Standard Type—Offset Adjustable Inclined Gage Fittings

Fig. 4-F

Fig. 12 Fig. 13

Leakless Super Try Cocks, Bronze and Forged Steel Construction

Send for Catalog 48P

Ernst WATER COLUMN & GAGE CO.
LIVINGSTON, N. J. LIVINGSTON 6-1400

CUTS WET—CUTS DRY
The NEW 1948
CLIPPER
MASONRY SAW

Model HD-48

The Masonry Saw with DUAL CONTROL

Yes, you can cut wet or dry with equal ease. The new HD-48 Clipper cuts dry just exactly the same as regular Clipper Masonry Saws . . and for DUSTLESS masonry cutting, just turn the control valve and use the circulating water system.

With the exclusive Clipper design proven throughout the world for 10 years . . . Guaranteed to provide the fastest cutting speed and the lowest cutting cost. You'll be amazed how quickly and easily you can cut virtually any special length or shape from the hardest masonry materials. Clippers save time — save material and assure better workmanship on every job.

CLIPPERS FOR EVERY JOB
Priced as low as $195. Write for catalog . . . Today!

CLIPPER CUTS ANYTHING

YOU CAN HAVE A CLIPPER ON FREE TRIAL

THE CLIPPER MFG. CO.
2820 WARWICK • KANSAS CITY 8, MO.
Philadelphia • Cleveland • St. Louis • Austin, Tex.

THE ONLY DAMPER THAT PROVIDES ALL THESE

OUTSTANDING FEATURES

The Heacon Damper is not only designed to perform the conventional functions of a damper more efficiently; it is also better designed, better engineered and better constructed.

From the Heacon designed dust-proof bearings to the leakless curtain seals . . . from the ample drive shaft that prevents sagging and binding, to the constant torque drive requirement that results in smoother control, "Heacon" stands for a damper you can depend on for years of better service.

And . . . the Heacon Damper seals tight, providing important operating savings, making possible a smooth flow curve for more efficient control. Motor or manual operation is optional.

Write for full information on this truly modern Damper.

FIELD PROJECT ENGINEERS

ATLANTA, GA.
C. E. Johnson & Associate
Bona Allen Building

BOSTON 10, MASS.
Thermix Engineering Co.
88 Broad Street—Room 610

BUFFALO, N. Y.
Johnston Engineering Co.
1200 Niagara Street

CHARLOTTE 2, N. C.
T. C. Heyward
1408 Independence Bldg.

CHATTANOOGA 2, TENN.
Edgar A. Rogers
Chattanooga Bank Bldg.

CHICAGO 51, ILL.
Engineering Sales Co.
816 North Kostner Ave.

CINCINNATI 2, OHIO
Ellman Equipment Co.
1017 Chamber of Com. Bldg.

CLEVELAND 15, OHIO
H. W. Kaiser Company
1836 Euclid Ave.

DETROIT 2, MICH.
Metrol Company
5538 Cass Avenue

HOUSTON, TEXAS
J. A. Rossiter Company
P. O. Box 1095

KANSAS CITY, MO.
F. W. Hay & Company
2734 Cherry St.

LOS ANGELES, CALIF.
A. W. Anderson
164 So. Central Ave.

MINNEAPOLIS 2, MINN.
Hoyt A. Sevey
314 South 9th St.

MONTREAL 25, CANADA
T. C. Chown, Ltd.
1440 St. Catherine St., W.

NEW HAVEN 5, CONN.
Daniel Smerling
P. O. Box 1169

NEW ORLEANS, LA.
Arthur C. Hays
1221-23 Carondelet Bldg.

NEW YORK 7, N. Y.
Parry Engineering Co.
154 Nassau St.

PHILADELPHIA 3, PA.
Thermix Engineering Co.
1003 Broad St. Station Bldg.

PITTSBURGH 19, PA.
Herr-Harris Company
545 William Penn Way

PORTLAND 5, ORE.
Lee & Freeman, Inc.
432 Governor Bldg.
408 S. W. 2nd Ave.

RICHMOND 1, VA.
Frank Howell Company
Room 412, American Bldg.

ROCHESTER 4, N. Y.
Johnston Engineering Co.
31 Gibbs Street

ST. LOUIS 8, MO.
Economy Equipment Co.
4526 Olive Street

SALT LAKE CITY 9, UTAH
The Lang Company
267 West First South

SAN FRANCISCO 4, CALIF.
S. Herbert Lanyon
58 Sutter Street

SCHENECTADY 4, N. Y.
D. R. Whipple
1550 State Street

SEATTLE 4, WASH.
Lee & Freeman, Inc.
1550 First Avenue South

WASHINGTON 11, D. C.
T. W. McGuire Co.
137 Kennedy St., N. W.

Project and Sales Engineers

THE THERMIX CORPORATION

FIRST NATIONAL BANK BLDG. **GREENWICH, CONNECTICUT**

Experience with Burning Bagasse on Spreader-Type Stokers

By H. G. MEISSNER
Combustion Engineering Company, Inc.

Review of the first season's experience with a unit burning bagasse by means of a spreader stoker installed at a Cuban sugar mill. Operation has been marked by high sustained capacity, high availability, good efficiency and ease of handling.

CONTINUED operation of a spreader-stoker equipped boiler burning bagasse at a Cuban sugar mill has fully confirmed the advantages anticipated for this method of firing such fuel as compared with the dutch-oven furnaces at this mill. The boiler was put into service at the start of the current crop and, except for the normal Easter holiday and a mill shutdown caused by rain, it was kept in continuous operation until the end of the crop.

Designed for a maximum continuous output of 60,000 lb per hr, this two-drum boiler has operated continuously at 75,000 lb to 80,000 lb, with peaks up to 85,000, the limit in capacity being reached when the induced-draft fan damper is wide open.

This boiler output has been maintained for months at a time, as it has not been found necessary to drop the load for cleaning, deslagging or other maintenance work. The monthly steam output has, therefore, been materially greater than that from similar sized boilers fired by other methods, so that in this particular case it has been possible to increase the grinding rate substantially, largely as the result of this high sustained capacity. At the same time the consumption of fuel oil has been drastically reduced.

High Availability

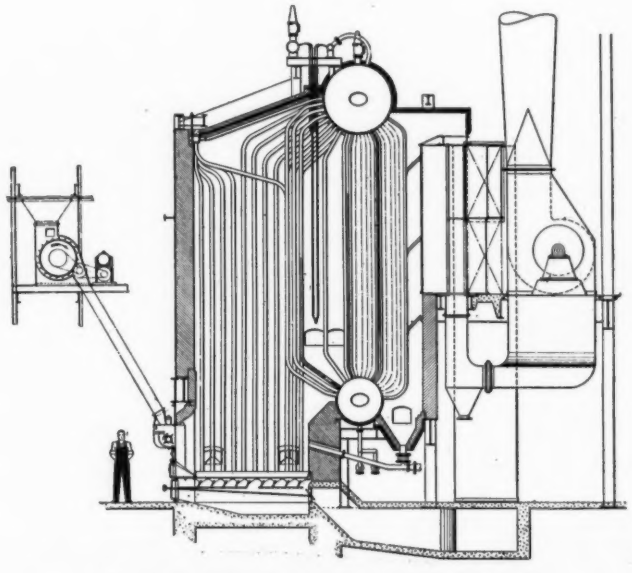
The absence of slag and ash accumulations in either the furnace or the boiler is in marked contrast to the troubles usually experienced in the dutch-oven furnaces, the availability factor of the new boiler for the duration of the crop being practically 100 per cent. Complete oxidation of the fuel in the thin fuel bed and low gas velocity in the wide open furnace have eliminated any troublesome build-up of slag on the boiler or side wall tubes. Water cooling in the furnace of such a unit is satisfactory as spreader-stoker firing is not dependent on hot refractory for drying and igniting the green fuel.

Operation has been stable and is easily controlled. The hopper mounted below the conventional bagasse conveyor is kept full at all times, the surplus bagasse being carried along to the next boiler or to storage. The rate of feed to the furnace is, therefore, controlled by the speed of the specially designed rotary feeder, mounted at the base of this hopper. This rotary feeder is motor-driven through a variable-speed mechanism and discharges the bagasse by gravity chutes to the rotary distributor, which projects the fuel into the furnace in a thin, uniform and widely dispersed stream. The blades welded angularly to the drum insure proper lateral distribution.

As the distributor is located several feet above the grate surface, the bagasse particles are flash dried as they enter the hot gas stream in the furnace and, depending on their size and moisture content, are either burned in suspension or drop onto the grate to complete their combustion. The distributor is driven by a motor and variable-speed pulley mechanism, and operates at about 400 rpm.

Grate Easy to Clean

The grate surface, 18 ft wide by 9 ft long, is continuous across the width and length of the furnace. For ease in cleaning, the grate bars are divided into four sections, corresponding to the number of distributor units, and the ashpit is divided into equivalent sections, each section having its own shut-off damper and cleanout door. Of



Section through steam generating unit

course, it is possible in such installations to adapt the width and length of the grate surface to fit a wide range of boiler sizes.

Variations in the moisture content of the bagasse from 45 to 55 per cent or more have had no noticeable effect in the furnace, and variations in the quality or sizing of the bagasse are readily compensated, when necessary, by adjustment of the feeder output and distributor speed.

All the forced-draft air is supplied through the grate, the control of this air being accomplished by regulating the speed of the turbine-driven forced-draft fan. It is, therefore, possible to operate at all times with a minimum of excess air, the best results being obtained with 20 to 15 per cent excess at the boiler outlet, corresponding to 16 to 17 per cent CO_2.

The fuel bed has been found to remain thin and uniform at all ratings, there being little or no piling to interfere with air flow. Hence the fire is bright and active over the entire grate surface. Actual fuel bed thickness averages 2 to 3 in. The ash builds up below this active fuel bed to a thickness of approximately 2 in. in eight hours of running.

Fires Little Affected by Short Interruptions in Fuel Supply

Temporary reduction in the bagasse supply, such as occurs during a tandem choke, causes no more than an equivalent reduction in boiler output, the steam flow returning to normal when the fuel supply is restored. The thin fuel bed is able to retain sufficient heat during normal periods of fuel interruption to rekindle the incoming fuel quickly, so that no trouble from this source has been experienced during a full season's operation comprising the crop period.

Cleaning of the fire has proved to be a quick, easy operation, accomplished without noticeable change in boiler output. The grates are dumped, one section at a time, without changing the rate of feed of the bagasse. The shut-off damper for this section of the grate is then closed, and the ashes are removed at floor level through the cleanout door. Natural-draft air flow through this door supports combustion of the bagasse, which becomes ignited from the adjacent sections of the fuel bed. Closing the cleanout door and opening the shut-off damper quickly restores this grate section to full heat output, after which each of the remaining sections is cleaned in a similar manner. Three of the four grate sections are, therefore, always in normal operation during this cleaning period.

Power cylinders, operated by either compressed air or steam, dump the grates quickly, the entire operation on this four-section grate requiring approximately 20 minutes. About a wheelbarrow full of ash is removed from under each grate section during a normal eight-hour cleaning schedule.

The ash discharged to the pit is well burned out, loose and free from clinkers. In fact, it is so cool that lightweight wooden scrapers have been used for its removal. Ease of cleaning the fire makes this unit especially popular with the operators.

With stoker firing it is usually unnecessary to open the fire doors while cleaning the grates, as the peep holes serve to show when the ash has been discharged. Cooling of the furnace by admission of an excess of air is, therefore, avoided, and the CO_2 charts show little or no change during this period.

The carryover of cinder, or bagacillo, is moderate, and most of what leaves the furnace is collected in the hoppers under the lower boiler drum, from which it is returned to the furnace by the cinder reinjection system for reburning. Cinder or carbon loss is, therefore, very small.

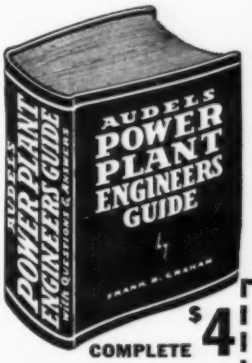
Use of air preheated to 390 F has proved entirely satisfactory; and although preheated air is not considered essential, it is believed desirable as a means of promoting more rapid and complete combustion of the fuel, with a minimum of excess air, thus assuring maximum boiler capacity and efficiency.

The combination of low exit gas temperature, low excess air and small carbon loss has resulted in an overall efficiency of 67 to 68 per cent as compared with much lower efficiencies for the other boilers in the plant. These efficiencies are based on week-in and week-out operation, rather than on short tests, as such short tests do not take into account the outages for cleaning, deslagging and repairs, which have heretofore been considered unavoidable.

This increased efficiency is desirable in that it permits accumulation of a more adequate supply of bagasse to carry over mill cleaning periods. It also permits the utilization of the excess bagasse for other than fuel purposes when conditions permit. Meanwhile the reduction in fuel oil consumption compared with other years has been very gratifying, especially in view of the present high price of this oil.

When fuel oil must be used, as during the idle season or in emergencies, the greater efficiency of the boiler equipped with an air heater will be especially desirable as the reduction in oil consumption will range from 10 to 15 per cent compared with the usual practice. The use of modern forced-draft oil burners and air preheaters should permit operation at 83 to 85 per cent efficiency. The furnace design, as illustrated by the cross-section, is well adapted to application of oil or gas burners, either through the front wall or under the lower boiler drum when setting height is ample.

The satisfactory operation of this initial spreader-stoker-fired boiler has resulted in the purchase of similar units both in Cuba and Mexico; and the favorable reactions of visiting engineers have indicated that this method of firing bagasse will receive wide acceptance as its merits become generally known.



$4 COMPLETE

PAY ONLY $1 A MO.

Get this information for Yourself. Mail Coupon Today. No Obligation Unless Satisfied. ASK TO SEE IT.

ENGINEERS INFORMATION ★ ★ ★

QUESTIONS and ANSWERS

JUST OUT! Audels Power Plant Engineers Guide. A complete Steam Engineers Library covering Theory, Construction & Operation of Power House Machinery including Steam Boilers, Engines, Turbines, Auxiliary Equipment, etc. 65 chapters, 1500 Pages, over 1700 Illustrations. 1001 Facts, Figures and Calculations for all Engineers, Firemen, Water Tenders, Oilers, Operators, Repairmen and Applicants for Engineer's License.

FREE TRIAL!

AUDEL, Publishers, 49 W. 23 St., New York 10

MAIL AUDELS POWER PLANT ENGINEERS GUIDE for free examination. If O. K. I will send you $1 in 7 days; then remit $1 monthly until price of $4 is paid. Otherwise I will return it.

Name_____

Address_____

Occupation_____

Employed by_____ CBN

"We can solve your **coal** problem!

If this is what you need"

QUALITY

Highest quality coal with guaranteed uniformity through careful inspection. Correct and proper sizing helps meet your specific needs.

DEPENDABILITY

Twenty-one years of coal experience assures you that you can rely on receiving exactly what you order —not a substitute.

SERVICE

When you order you can expect the shipment to be scheduled properly and made flexible to suit your specifications. Sales and Service offices in the principal cities bring coordination between your order and our shipment.

SNYDER & SWANSON, INC.

Coal Merchandisers

Main Office: **Pittsburgh 16, Pennsylvania**

Telephone: LEhigh 1000

Branch Offices: **NEW YORK**
CLEVELAND
BALTIMORE

Shipments by **RAIL**
LAKE
TIDEWATER

Some Recent Court Decisions Affecting Owners and Operators of Steam Plants

The views herein expressed are those of the Courts rendering the reported decisions as interpreted by the author who abstracted them for this article. Publication of the article in this magazine does not imply that it reflects the opinion of the magazine. As suggested by the author, readers who desire to review any decision in detail may refer to the citation and obtain the full decisions from a library—Editor.

By LEO T. PARKER

Attorney at Law, Cincinnati, O.

DURING the past few weeks the higher courts have rendered numerous decisions involving, directly or indirectly, steam plants and engineers. A review of these decisions should assist readers in avoiding similar expensive law suits. Also, since many of the decisions here explained reverse the older law the citations may be used to win unavoidable suits. The decisions are briefly explained, but readers who desire details may refer to the citation and read the complete decision in any good library.

Manufacturer Liable

According to a recent higher court, one who infringes a patent is liable in full damages to the inventor. Furthermore, a manufacturer who makes and sells a device which is not patented is guilty of unfair competition if the testimony shows that the inventor entrusted the manufacturer with his plans of the unpatented invention.

For illustration, in *Consolidated Boiler Corporation v. Bogue Electric Company, 58 Atl. (2d) 759,* the testimony showed facts as follows: Sometime in 1945 one Burkhart had an idea for a new type of vertical tubular heating boiler. He planned to apply for a patent for the boiler and to place it on the market. He submitted sketch to a manufacturer who had the plant and facilities to manufacture the boiler. An agreement was made whereby the manufacturer would manufacture and sell the boilers and pay the inventor a royalty. Two important questions were decided by this court first: Where a manufacturer violated an agreement with a patentee and made and sold similar boilers, and infringed the patent the patentee is entitled to recover *either* manufacturer's profits, or full damages sustained resulting from the manufacturer's infringement.

Second, a manufacturer which makes and sells a device in accordance with specifications (which a patentee had *secretly* entrusted to the manufacturer) is guilty of unfair competition which the court will enjoin from doing these things.

Compensation v. Damages

A recent court decision held that an injured employee who is denied compensation under the State Workmen's Compensation Act cannot sue and receive damages from his employer.

In *Morris v. Ford, 31 N. W. (2d) 89,* it was shown that an assistant engineer in a plant noticed a bloating and sour condition of his stomach and went to the company's first aid department where he received some soda and epsom salts. Shortly thereafter he began to suffer cramps, left his work and went home. Later he underwent an operation, which disclosed a ruptured appendix. He filed a claim for workmen's compensation.

The Industrial Commission refused to award compensation to the injured employee on the grounds that the injury did not arise out of and in the course of his employment. Then the employee sued the company for damages.

The higher court refused to allow any damages stating that when an employee files an application for compensation under the State Workmen's Compensation Act he cannot thereafter receive damages based upon an inconsistent theory. The court said:

"Having adopted one theory before the Compensation Commission, he may not thereafter bring other proceedings based upon an inconsistent theory or claim."

Trespasser Is Injured

Considerable discussion has arisen from time to time over the legal question: Can a plant owner be held liable in damages for injuries sustained by trespassers? The answer is yes, if the injury was caused by the willful or wanton negligence of an employee.

In *Banks v. Watts, 44 S. E. (2d) 510,* a trespasser sued a plant owner to compensate for burns he sustained from carelessness of the boiler room attendant when he let steam escape from a pipe. The counsel argued that the plant owner could not be liable because the injured person was a trespasser. Nevertheless, the higher court held that the employer was liable because gross negligence of

his employee in permitting steam to escape caused the injury. The court said:

"The deflection of the pipes downward, or to protect them by hoods, could easily have been done, and the peril thereby removed."

Scope of Employment

It is well known that an employee injured "outside the scope of his employment" cannot recover compensation for the injury. However, if he is injured while doing something *for the benefit* of the employer, or for the *mutual benefit* of both, an injury is compensable.

In *Linderman v. Cownie, 13 N. W. (2d) 677*, it was shown that a company paid all expenses of certain of its employees who went on a fishing trip. One afternoon four employees set out in a motorboat to where they intended to fish, but enroute the boat sunk and one was drowned. His dependents sued the company for compensation under the State Workmen's Compensation Act. In holding the corporation liable, the higher court said:

"It is undisputed that the company paid all expenses, including meals and transportation in the cars and launch and the company provided the motorboat..... There was evidence that the fishing trip was a part of the company's business enterprise designed to stimulate its employees to greater efforts."

Should Sue Manufacturer

Considerable discussion has arisen from time to time over the legal question: If a manufacturer, retailer and user of a patented device infringes a valid patent, who should the owner of the patent sue for infringement?

In *Salem Engineering Company v. National Supply Company, 75 Fed. Supp. 993*, the holder of a patent sued the National Supply Company for alleged infringement of a patent pertaining to a furnace. The testimony showed that the National Supply Company had purchased the furnace from its manufacturer. The Federal Court held that the suit should be brought against the wrongful manufacturer rather than against customers of the manufacturer. The court said:

"Public policy favors the rule that litigation for the purpose of ascertaining and sustaining alleged rights of a patentee or manufacturer should be brought against the alleged wrongful manufacturer rather than against the customers of the manufacturer. The effect which may reasonably be anticipated of harrassing the purchasers of a manufacturer by claims for damages would be to diminish the manufacturer's opportunities for sale. No one wishes to buy anything, if with it he must buy a lawsuit."

Fair Labor Standards Act

All employees who produce or handle merchandise for interstate commerce must be paid wages specified by the Fair Labor Standards Act.

According to a recent higher court employees who are employed to "experiment" do not "produce" merchandise for interstate commerce.

For example, in *Krill v. Arma, 76 Fed. Supp. 14*, it was shown that one Krill was employed as an assistant to a senior engineer. Krill did experimental work, constructed experimental models and tested equipment. He sued his employer to recover overtime and back wages under the Fair Labor Standards Act. In refusing to hold in favor of Krill, the court said:

"The plaintiff (Krill) must fail because he was not engaged in commerce or in the production of goods for commerce within the meaning of the Act."

Also, this court held that persons employed in a professional capacity are exempt from the Fair Labor Standards Act.

Defective Insulation

A higher court held that a company in the business of installing boilers is negligent if the evidence shows that the boiler was not properly insulated and the real property was thereby damaged.

For illustration, in *Hinchman, Rolph & Landis v. Golding, 192 Pac. (2d) 489*, it was shown that the owner of a plant relied upon judgment of the contractor, engaged in business of installing heating boilers, to make a safe installation. The boiler was improperly installed and caused a fire.

The court promptly held the contractor liable for $2,554 full damages, and said:

"A contractor is liable for fire loss caused when heat from a boiler installed by it set fire to an unprotected wooden floor, where the evidence established that the boiler was negligently installed."

Negligence of Repairman

Considerable discussion has arisen from time to time over the legal question: When is a service company liable for damages caused by its repairman? The answer is: When negligence or lack of ordinary care on the part of the repairman caused the damage.

For example, in *Burr v. Clark Company, 190 Pac. (2d) 769*, a property owner sued the Clark Company for damage done when a heating boiler burst.

The property owner testified that the boiler burst after the company's repairmen had repaired the system and admitted water into the boiler. The testimony showed that the boiler would not have burst if the pressure had been kept within the safe limit, even though the relief valve were not properly working at the time.

The counsel for the Clark Company argued that the property owner was at fault because the relief valve was out of order. Nevertheless, the higher court held that the Clark Company must pay damages, saying:

"Although Smith (repairman) may have been entitled at first to rely upon the assumption that the relief valve was in proper working order, nevertheless when the black hand on the dial did not go back, he had notice that the relief valve was not working, and that the addition of more water would increase the pressure far beyond the danger point. Under these circumstances, Smith was charged with the duty to exercise at least such care as a reasonably prudent man would exercise under similar circumstances."

Nuisance Liability

According to a recent court opinion, a legal nuisance may be created by smoke, soot or gases which are cast upon the property of another to his physical discomfort or injury, and the owner of a steam plant may be liable for maintaining such a nuisance. In cases of this kind

the jury will decide the amount of damages due the complaining owners of adjacent property.

For example, in *Frey v. Queen City Paper Company, 66 N. E. (2d) 252*, the owners of dwellings sued the Queen City Paper Company for damages. The property owners alleged that fine particles of matter or fly ash emanating from the stack penetrated window ledges and entered the living room and sleeping quarter and was deposited on the furniture, floors, etc. They introduced testimony tending to prove that the fly ash was deposited on the ground and on vegetation, preventing the gardens from growing properly. The court agreed that the property owners were entitled to damages awarded by a jury, saying:

"The amount of detriment sustained is not susceptible of exact pecuniary computation. It is for the court to say what sum of money the plaintiff (property owner) should receive in view of the discomfort or annoyance to which he had been subjected."

For comparison, see *Dauberman v. Grant, 198 Cal. 586*. This court said:

"It is not necessary to recover to show actual damage to property caused by the nuisance of smoke and soot, as one is entitled to recover for personal discomfort and annoyance to which he has been thereby subjected"; and "it is a question for the trial court to determine the amount of the compensation which he should receive."

Again, in the case of *Premier Company v. Hansford, 44 S. E. (2d) 126*, a property owner, Hansford, sued the Premier Company for damages for the maintenance and operation of an alleged nuisance. He proved that the company maintained a steam boiler and smoke stack in the rear of its plant and that wind currents are such that smoke and soot from the company's stack are almost constantly blown against his dwelling. Counsel for the company argued that Hansford had no legal right to file a suit for damages. The higher court refused to agree with this argument, saying:

"The injury produced by lawful business is actionable if it produced that which is offensive to the senses and which renders enjoyment of life and property uncomfortable."

Not a Nuisance

Notwithstanding the foregoing decisions which held operators of steam plants liable to owners of nearby property, yet a new higher court decision held that if a steam plant is operated by experienced and capable engineers and at high efficiency the plant owner is not liable for damages.

In the case of *Schott v. Appleton Company, 205 S. W. (2d) 917*, it was shown that certain property owners sued a company for damages claiming that it maintained a nuisance comprising machinery, boilers and heating systems which consumed large amounts of stoker-fired coal and that fly ash, soot, cinders and smoke are emitted from the stack and deposited in great volume on their homes causing much damage.

The company proved that it is using appliances and equipment which are modern and designed to eliminate the alleged nuisance. Also, the company introduced testimony showing that it employs competent engineers and firemen; that some smoke, fly ash, soot and coal dust is discharged from the smoke stack, but no more than is necessary in the proper and reasonable operation of their business.

In holding the company not liable the court said:

"There was testimony that the plant at the time of trial was operating with 85 to 90 per cent efficiency, which is all that could be reasonably expected, as a total elimination is not possible."

$5,000 for Burns

According to another court there is no set formula for estimating damage allowance to an engineer for pain caused by burns.

For example, in *Roura v. Mississippi Company, 75 Fed. Supp. 591*, it was shown that a junior engineer was injured and burned in a boiler room from a flareback from one of the furnaces. He sued for damages claiming that more than one year after the accident his left leg had a tendency to cave in as he walked; his left eye was permanently injured; and had pains in his head and hands. The court held:

"There is no formula by which pain and suffering can be estimated. However, the injuries were for a number of weeks severely painful, and thereafter to a lesser degree. Also, initially he did sustain some shock. What with the loss of earnings during the period of hospitalization and subsequent treatment, he should be awarded the sum of $5,000."

Call to Policeman

It would appear that owners and other operators of steam power plants may avoid liability for injuries to unruly or disorderly persons by calling the police department. This is so because the police department is a governmental agency of the city, and a municipal corporation is not liable in damages for negligence of its police officers as the following case shows.

In *O'Quin, 201 S. W. (2d) 694*, the testimony showed facts, as follows: One O'Quin caused a disturbance and then entered a boiler room. Someone telephoned the police department. When the policemen entered the boiler room O'Quin picked up a piece of old water pipe and struck one of the policemen, breaking the latter's arm, and then turned and advanced on the second policeman, who shot and killed him. Relatives of O'Quin sued for damages. The higher court held the relatives not entitled to damages, and said:

"Private individuals or corporations are not liable who call police officers in to quiet a disturbance, unless these private persons or corporations do something in furtherance of the unlawful act....."

Measure of Damages

The measure of damages for permanent injuries to land resulting from a permanent nuisance, is the difference between the reasonable value of the land immediately before and immediately after the injury.

In *Goodyear Tire & Rubber Company, Inc., v. Gadsden Company, Inc., 25 So. (2d) 578*, the Gadsden Company sued a corporation for $100,000 damages contending that the latter corporation had erected a dam on its own property which prevented the natural flow of surface waters and caused seepage and percolation. It was proved that the dam caused water to accumulate, overflow and stand on the property of the Gadsden Company.

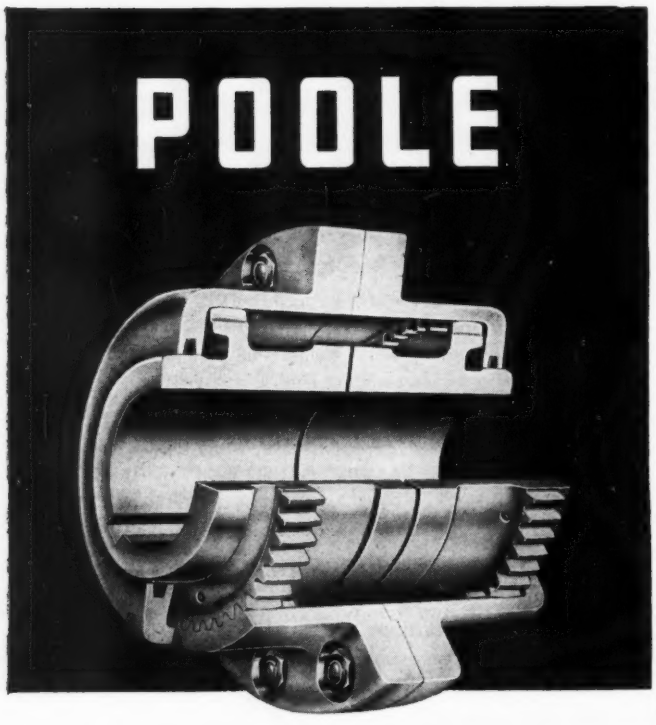
The court held that the Gadsden Company could recover damages from the corporation equal to the difference between the value of its property before and after the dam was constructed.

Legal Fixture

Frequently plant operators and property owners make lease contracts which give them the right to install machinery, chattels and improvements to be removed at the termination of the lease. It is important to know that the agreement cannot be enforced by the plant operator if the building will be permanently damaged by removal of the equipment or improvements that have been made by the tenant during the term of the lease.

For example, in *Forman v. Columbia Company, 148 Pac. (2d) 951*, it was shown that the owner of real premises and an operator signed a lease contract. This contract contained a clause that the operator was privileged to install equipment and make various improvements, and that the operator could remove same at termination of the lease.

In subsequent litigation the court held that the operator could not remove items whose removal would damage the building. However, it held that the operator could remove from the building such items as equipment that was merely bolted to the floor.



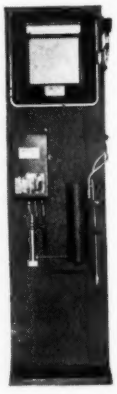
A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY WOODBERRY, BALTIMORE, MD.

PREVENT BOILER CORROSION

Oxygen, one very active source of destructive corrosion, is continuously detected and recorded by the Cambridge Dissolved Oxygen Analyzer. The oxygen dissolved in the feed water is determined directly. The oxygen set free by dissociation in the boiler is determined by measuring the free hydrogen in the steam. Cambridge Analyzers are available in models for recording O_2, H_2, or both O_2 and H_2 simultaneously.

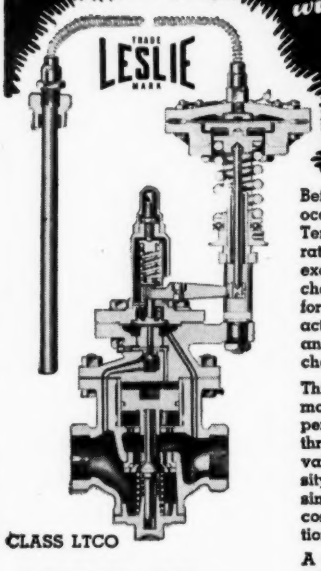


Send for Bulletin 148 B.P.

CAMBRIDGE DISSOLVED OXYGEN ANALYZERS

CAMBRIDGE INSTRUMENT CO., INC.
3769 Grand Central Terminal New York 17, N. Y.
Pioneer Manufacturers of
PRECISION INSTRUMENTS

The Temperature Regulator with Anticipating Action!



CLASS LTCO

Before a process temperature variation occurs at the bulb of the Leslie Class LTCO Temperature Regulator, a change in the rate of steam condensation in the heat exchanger creates a steam pressure change which is automatically corrected for by the basic pressure reducing valve action of this regulator—thus anticipating and minimizing the actual temperature change at bulb location.

This Regulator is a self-contained Duomatic Regulator which controls both temperature and pressure within a given throttling range with a single internal pilot valve. This design eliminates the necessity for a separate pressure reducing valve, simplifies piping and reduces installation costs. It provides an accuracy of regulation comparable to instrument control.

A temperature deviation from the control setting produces a characteristic change in delivered steam pressure of 4-5 psi per °F. This characteristic is ideal for most temperature control problems involving industrial heating equipment.

LESLIE CO.
303 Grant Ave.
Lyndhurst, New Jersey

WRITE FOR *your copy of Bulletin 464-A*

1559

ESTABLISHED 1900 LESLIE CO.

PRESSURE REDUCING VALVES • • PRESSURE CONTROLLERS
PUMP GOVERNORS • • • TEMPERATURE REGULATORS
SELF CLEANING STRAINERS • • LESLIE-TYFON WHISTLES

POWER STATION LAYOUTS

An interesting discussion of layouts for steam power stations, with particular reference to a comparison of the unit system with the so-called collective system, is contained in the Brown Boveri Review (Switzerland), Vol. XXXV, Nos. 1 and 2, just received. Feed heating under both arrangements is considered. Following are some excerpts from these observations.

THE unit system of plant layout, in which boiler, turbine, auxiliaries, feed heating, generator and transformer are operated together as a single unit, is today being employed for most new steam generating stations. As it dispenses with all connections between the individual machine sets, it results in the simplest and safest arrangement and the most economical from the point of view of installation costs and efficiency. It allows a clear layout and permits the condensing and feedwater heating and treatment plants to be operated in a simple and reliable manner.

Furthermore, the unit system results in an amazing simplification of the piping, because all ring mains and collector piping for steam, water and air are redundant. Many fittings which are not used for years, but require maintenance, are rendered unnecessary. This system is particularly desirable in the case of high-pressure installations.

In the collective system, which was previously in vogue, all the boilers and their auxiliaries are grouped, as are the turbines and their auxiliaries, and operated as such. Experience indicates that this system should now be employed only when installing new boilers or turbines in existing stations that employ such a layout. The individual grouping of the boilers, pumps, turbines, transformers, etc., into a special section gives a *theoretically* higher service availability for the whole installation, since any desired units can be operated together. However, the mutual interconnections of the sections entail so many additional possibilities of breakdown that nothing is gained in practice as regards service availability.

Today availabilities of around 95 per cent can be expected for boilers and turbines; hence the mutual interconnection of the sections as it occurs with the collective system is no longer justified. As soon as an extension with new boilers, turbines and buildings is proposed, transition to the unit system is to be recommended. This allows complete freedom of choice for steam conditions and, therefore, permits taking advantage of all technical improvements; also a very high service reliability can be expected.

For the two systems different arrangements of feed heaters and feed pumps are necessary. Furthermore, for high boiler pressures and high feedwater temperatures only the unit system gives a completely satisfactory layout and mode of operation. Based on experience, definite layouts are recommended in accordance with various pressure ranges and operating practices.

Feed Heating with Unit System

With the unit system quantities of steam and feedwater, corresponding to the load, circulate from the boiler through the turbine, condenser, feed-heating plant and feed pumps, back to the boiler. Heating of the feed by means of steam bled from the turbine always corresponds to the quantity of condensate. Fundamentally, in the case of the unit system, apart from the water capacities of the boiler and condenser, no container for preheated feedwater is necessary in the circuit. It is sufficient to have available in the station a common feedwater reserve for all sets in an open tank. Since however, in the case of boilers of large water capacity, it is usually desirable that the boiler feed be independent of the quantity of feedwater returning from the condenser, a medium-pressure feedwater tank is provided in which preheated feedwater sufficient for 10 to 20 minutes' full-load service may be stored. Furthermore, this tank is required because many feed regulators close the feed valve when it should be opened; that is, in the case of a sudden increase in load, when the boiler foams and simulates too high a water level at the regulator. In this event the condensate is stored in this medium-pressure tank independently of the feedwater.

With low and medium steam pressures only low pressure feed heaters located ahead of the boiler feed pump are recommended. The quantity of water flowing through these feed heaters is always proportional to the turbine load, and they receive heating steam at the corresponding pressure; that is, the feed heating is properly adjusted for every load. A simple layout (Fig. 1), an inexpensive installation and reliable operation are thus obtained.

In the case of high steam pressures and correspondingly high feed-heating temperatures, one or two high-pressure feed heaters must be arranged in the feed line after the pump (Fig. 2). For high feed temperatures one might also consider using the arrangement shown in Fig. 1, with only low-pressure feed heaters and all the advantages this entails. The only alteration necessary is that the medium-pressure tank would have to be constructed for a feedwater temperature of around 490 F and a pressure of about 425 psi. The disadvantage of such a system is that, although the condensate

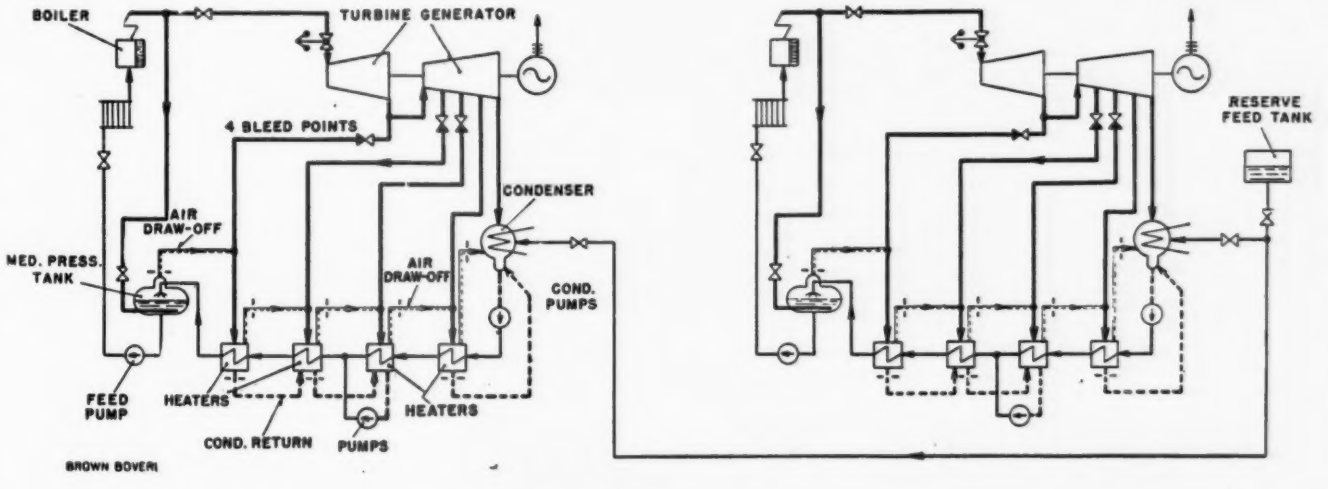


Fig. 1—Layout of feed heating for unit system employing low and medium steam pressures

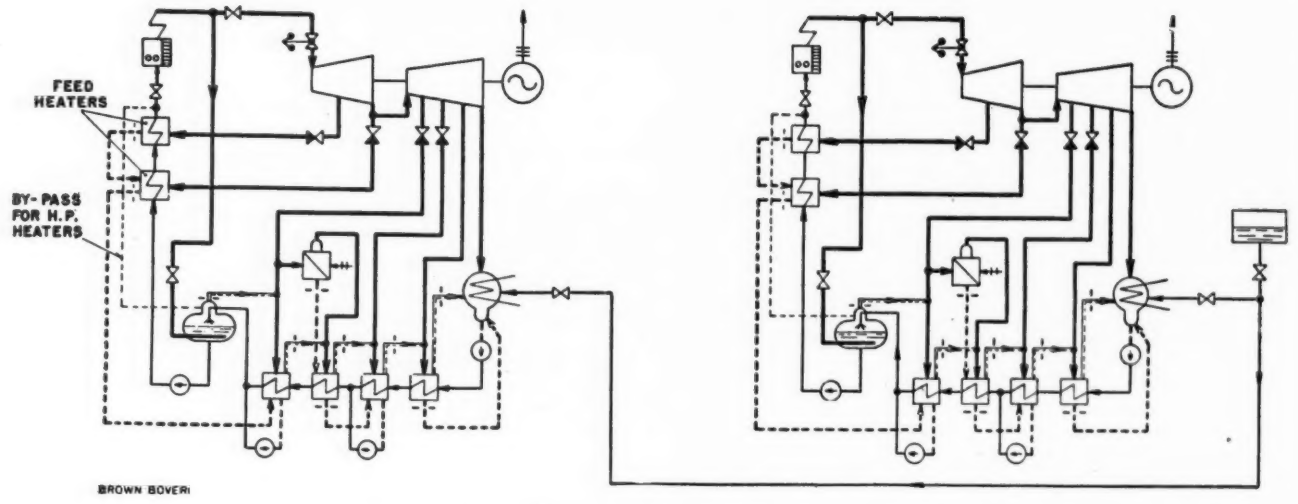


Fig. 2—Layout of feed heating for unit system employing high pressure and high feedwater temperature

pump delivers at the same pressure as that of the medium-pressure tank, the feed pump would have to deliver from approximately atmospheric to boiler pressure at no load and at partial loads.

The high-pressure feed heaters, which cannot always be avoided, must withstand the full feedwater pressure. Danger also exists that the flow of condensate through them will cease if the feed valve closes because of too high water level, and superheated bled-steam will then cause the water to evaporate with resulting water hammer and the tubes may suffer. This situation may be partly overcome by providing a bypass pipe to the medium-pressure tank from the boiler side of the last high-pressure heater.

STORE MORE COAL NOW! and Cut Handling COSTS
Above: Sauerman Power Scraper System stores and reclaims coal at a rate of 300 tons per hour. Sitting in a room above the receiving hopper, the operator sees every move of the machine and guides every move through simple automatic controls.
With the SAUERMAN
One-Man Scraper System
Stores and reclaims for few cents a ton
Adjustable to any space
Safe and clean
Simple maintenance
Sauerman Coal Storage Equipment will handle your storage job, large or small, for lowest cost. The Sauerman Power Scraper is a one-man machine that serves as a self-loading conveyor with large capacity and wide range. Making the best utilization of available space, it layers the coal evenly into a homogeneous pile protected against spontaneous combustion.
Installation and operating costs are surprisingly low. Our engineers will be glad to advise on your own problem.
SAUERMAN BROS., INC.
550 S. CLINTON ST., CHICAGO 7, ILLINOIS

Consequently, for medium steam pressures a feedwater temperature of 350 to 375 F is recommended in preference to the installation of high-pressure heaters.

Feed Heating with the Collective System

When the boilers and turbines are operated as two separate groups the boiler feeds, on the one hand, and the turbine loads and quantity of condensate of each turbine, on the other, are entirely independent. To make sure that the flow through the heaters of the individual turbine sets is correct, it becomes necessary to collect the heated condensate of the different machines in a common medium-pressure tank located at a high level or in several interconnected tanks. The feed pumps, which are independent of the turbines, draw from this medium-pressure tank and are located as low as possible. High-pressure heaters must be omitted as the boilers and feed pumps have no individual turbines assigned to them.

Minimizing Feedwater Losses

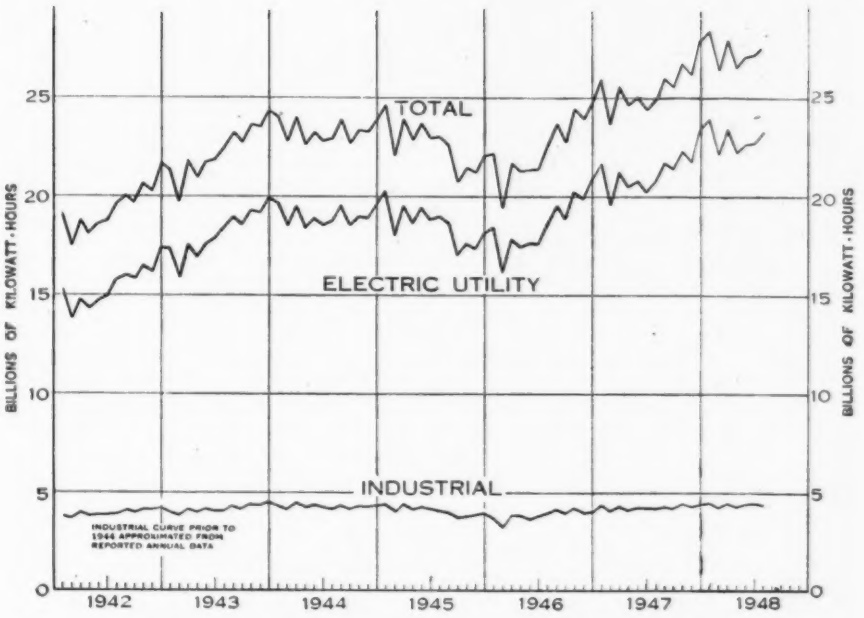
Every means should be employed to keep feedwater losses low so that only a small quantity of feedwater has to be prepared and a correspondingly small quantity of undesirable elements find ingress into the system. The evaporating plant then becomes small and requires little heat.

In order to reduce water losses to a minimum the labyrinth gland chimneys will be dispensed with in the case of large installations; and, instead, all the external glands of the turbines, valves and pumps will be connected to a gland steam leak-off condenser in which a slight negative pressure is produced by means of a fan or an injector. The steam loss from the glands and some air from outside are sucked into this leak-off condenser where the steam is condensed and the air exhausted to atmosphere. A steam jet air ejector is employed as a condenser air pump and most of the steam-air mixture from this is condensed in a cooler through

which condensate is passed. In order to recover as much water as possible the residual vapors are also led into the gland steam leak-off condenser.

With these precautions the water losses can be diminished to a fraction of one per cent of the feed; boiler operation is improved, and the production of the additional water is simple and inexpensive.

As a rule, the evaporators are connected to one of the feed-heater bled-steam pipes, and the vapor is condensed in the next lower feed heater or in a cooler located before the feed heater. However, this arrangement makes the turbine set more complicated by requiring additional valves and piping which increase the risk of air entry, and introduce in the vicinity of the turbine a degree of contamination. Furthermore, with the collective system it is not always satisfactory that the makeup water, used for all the boilers, be produced in evaporators associated with certain turbines only. For modern installations that require a small amount of makeup, a thermo-compressor plant may be used.



Output of electricity by utility and industrial plants

July Electric Output Up

Production of electric energy by utilities in the United States totaled more than 23 billion kilowatthours during July. Not only was this the highest July production on record, according to the Federal Power Commission, but it represented an increase of 12 per cent over July of last year. Of this hydro plants contributed 29.4 per cent.

For the twelve months ending July 31, 1948, the output was 271,444,303,000 kwhr which was an increase of 11.2 percent over that of the year ending July 31, 1947. If this rate is maintained output will have doubled in the next nine years.

Output of industrial power plants also increased but at a lower rate.

The accompanying curves show the steady post-war increase in electric utility load as well as the combined utility and industrial plant outputs. The average slope of the curves is comparable to the period from 1941 through the middle of 1943, although the output is greater.

Mobile Gas Turbine Plant

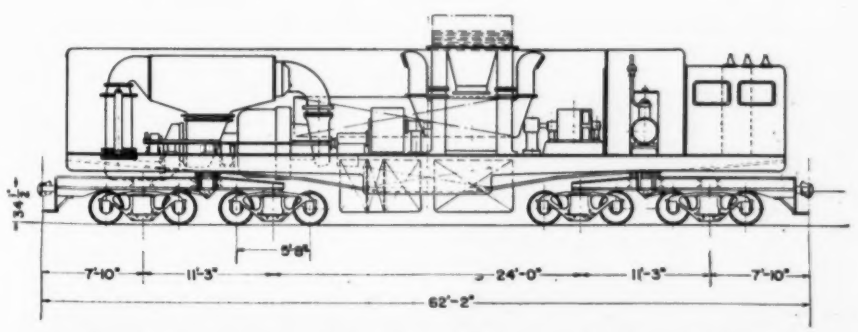
In a paper presented at the Fall Meeting of the A.S.M.E. at Portland, Ore., Sept. 8–9, Walter Giger of Allis-Chalmers Mfg. Co. outlined the design of a portable gas-turbine power plant for supplementing existing systems in times of power shortage.

The plant would be mounted on a standard-gage railway car carried by four freight car trucks. Two sizes are proposed—3000 kw and 6000 kw—and each would be self-contained except for the connections to an oil-tank car and to the transmission line of the system to be supplied. Moreover, sufficient oil-storage capacity would be provided on the smaller car to permit full-load operation for six hours, as a tie-over during tank-car changes. A small diesel-engine set would be installed for starting. The total weight figures 230,000 lb.

The smaller unit would employ an open-cycle gas turbine operating with 1300 F gas-inlet temperature and driving a 3-phase, 3600-rpm generator. An overall efficiency of about 23 per cent is expected.

The larger unit would employ a lower gas-inlet temperature of around 1150 F and would have a regenerator. Calculated efficiency is about 21 per cent. If a higher efficiency unit with limited life is desired, it can be built for 1300-F gas-inlet temperature, in which case the thermal efficiency would be boosted to around 23 per cent. The maximum output of the generator would then be increased to 7500 kw.

No water would be required for either plant.



Sketch of proposed 3000-kw mobile gas-turbine power plant

New Catalogs and Bulletins

Boiler Walls

New problems encountered in designing airtight refractory enclosures for modern water-cooled boilers and their solution are covered concisely in Bulletin 748 just released by the **Geo. P. Reintjes Co.**, Kansas City. It is confined to "floating walls" and employs the question-and-answer technique with simple sketches to explain the problems and their solutions.

Condensate Return System

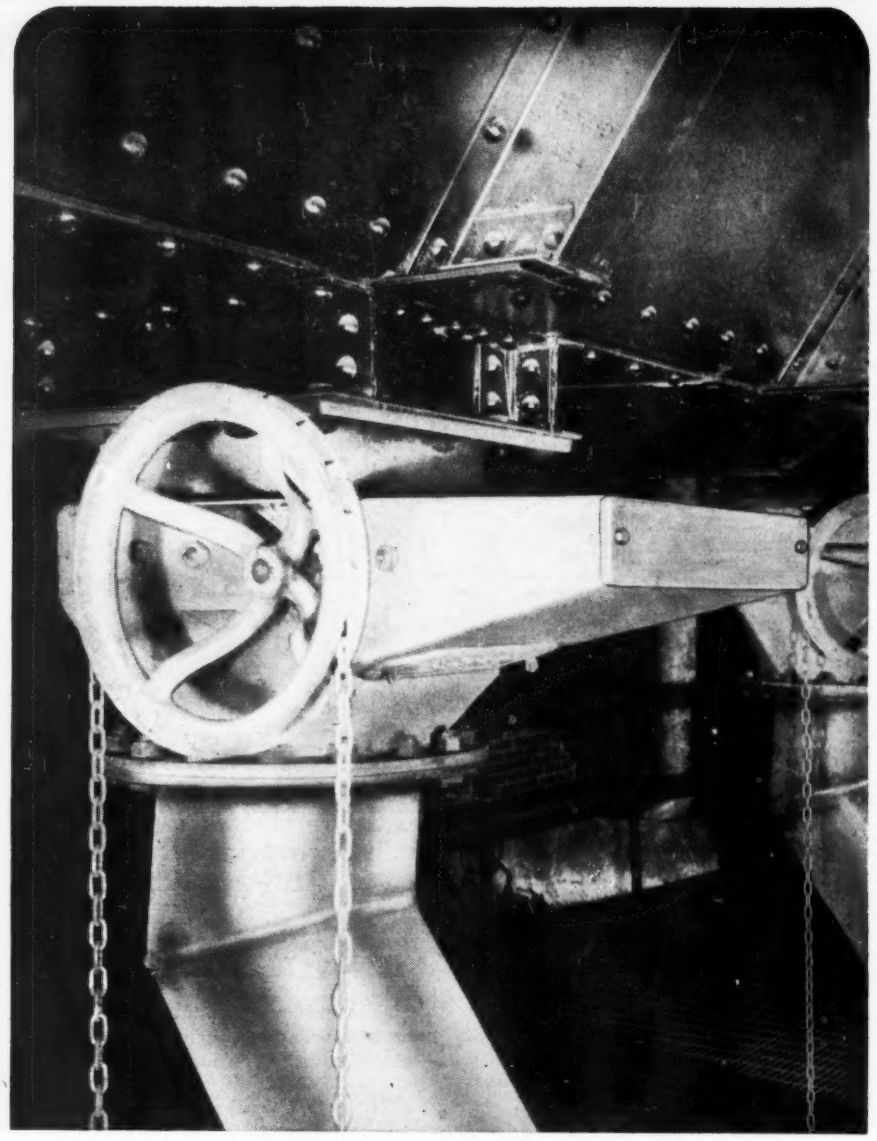
A specification bulletin on its new high differential high-pressure condensate return system has been published by **Cochrane Corp.**, Philadelphia. Capacity ratings are given for six different sizes up to 25 hp, based on a maximum of 200 psi pressure differential.

Desuperheaters

Schutte & Koerting Co., Philadelphia, has issued a new 8-page, 4-color bulletin describing its line of desuperheaters. These are of the venturi type, the surface-absorption type and the spray type. The bulletin contains diagrammatic drawings and pertinent technical data, as well as tables of dimensions.

Fan Control

A new 20-page booklet entitled "Precision Speed Control for Boiler Draft Fans with the Regutron Controlled Magnetic Drive" has been issued by Electric Machinery Mfg. Co., Minneapolis, Minn. In it is described the Regutron Control by means of graphs, diagrams and pictures.



HERE'S WHAT YOU GET WHEN YOU SPECIFY S-E-Co. COAL VALVES

- U-SHAPED GATE—gives you easy operation.
- ROLLER BEARING, ROLLER MOUNTED GATE—also gives you easy operation.
- DUST TIGHT CONSTRUCTION—gives you a clean boiler plant.
- DOUBLE RACK AND PINIONS—gives you a square closing gate.
- GASKETED ACCESS OPENINGS—give you opportunity for quick internal inspection.
- MANY SIZES AND TYPES—gives you valves that fit your requirements.

For bulletin, address
STOCK ENGINEERING COMPANY
713 Hanna Bldg. Cleveland 15, Ohio

STOCK ENGINEERING CO.
CONICAL
Non-Segregating
Coal Distributors
S.E.CO.
Coal Valves and Coal Scales

Gas Scrubbers

Peabody Engineering Corp., New York, has issued Bulletin H-204 describing its line of gas scrubbers and coolers. Included are diagrammatic sections and illustrations explaining the multi-stage and single-stage cooler and scrubber.

Induction Motors

Large induction motors of the squirrel-cage, wound-rotor type, with bracket and pedestal bearings are described in a new 24-page bulletin issued by **Allis-Chalmers Co.,** Milwaukee. It charts electrical characteristics, representing full-load power factors and the approximate range of starting torques of squirrel-cage motors larger than 200 hp. Also, a selection chart shows the range of standard open, 40-deg rise, continuous rated motors for both the bracket and pedestal bearing types.

Insulation

A 24-page catalog of the complete 48 group of high-temperature insulations, including charts and illustrations and data on the conductivity of both plastic and block insulation, as well as pipe covering, has been issued by **Forty-Eight Insulations, Inc.,** Aurora, Ill.

Liquid Level Indicators and Recorders

Two catalogs have been issued by **Yarnall-Waring Co.,** Philadelphia, one (WG-1822) dealing with "Yarway" remote liquid-level indicators for boilers, heaters, storage tanks, etc., and the other (WG-1830) covering "Yarway" remote liquid-level recorders for similar applications. The former, in addition to describing the liquid-level indicator which was first announced a couple of years ago, also deals with its extension to remote indication through a new attachment for operation of one or more distantly located electric-type visible or audible high-low alarm signals and/or controllers for pump motors or other devices in steam power stations and industrial plants.

The second bulletin supplements the first and shows how the actuating mechanism of the indicator has been incorporated in the design of the recorder.

Motor Selection

A handy guide for the quick selection of general purpose electric motors is contained in a new 12-page bulletin issued by Allis-Chalmers Mfg. Co., Milwaukee, Wis. It includes detailed specifications for squirrel-cage induction motors, and application data, range of sizes, speed-torque curves on synchronous, wound-rotor, and direct-current motors, Information is also given on motor controls.

Orifice and Flow Nozzle Data

While orifice-type meters are capable of providing accurate measurements of the flow of liquids, steam and gases through

pipe lines, proper sizing of the orifices and flow nozzles has sometimes been troublesome. Therefore, a simple method has been developed by the engineers of **Hagan Corp.**, Pittsburgh, which is described in a new bulletin designated T-100-M, under the title "Capacity Data for Concentric Orifices and Flow Nozzles."

Refuse Disposal

Allen-Sherman-Hoff Co., Philadelphia, has issued a 16-page catalog entitled "Hydrovac Materials Handling Systems" which is arranged to aid in the selection of equipment to handle dry materials ranging from dust to sizable lumps. Descriptions and layouts are included.

Roofing

Smoke, fumes and other corrosive agents produced by many industrial plants often make those plants the worst enemies of their own roofs, according to an illustrated, 24-page booklet published by **The International Nickel Co., Inc.** Full data on a new, soft-temper monel roofing sheet, designed to overcome severe roofing conditions, is presented in nontechnical language. Some of the nation's notable buildings, including power stations, having monel roofs are pictured in the booklet.

Test Sets

A new bulletin, No. 220, issued by **F. W. Dwyer Mfg. Co.**, Chicago, describes its combustion test sets, including CO_2 indicator, draft gages and stack thermometer for testing the efficiency of oil burners, combustion in furnaces, and affording other pertinent information concerning the performance of heating plants.

Tube Cleaners

To remove scale and other deposits from tubes as small as $^1/_2$ in. inside diameter, the **Roto Div. of Elliott Co.**, Newark, N. J., has developed a new line of Junior Rotojet cleaners. These are described and illustrated in a recently issued bulletin, J-410.

Valve Packing

Edward Valves, Inc., East Chicago, Ind., has issued a new catalog descriptive of all types of "Evalpak" die-molded packing. Full details and prices of sets for each size and pressure class of Edward steel valves are included.

Water Treatment

A new 20-page booklet dealing with water-treatment problems and methods of solving them has just been made available by **The Bird-Archer Co.**, New York. The text covers the broad subject of industrial water treatment from simple basic theory to specific problems involved in the use of water for power, process and cooling. It is intended primarily for plant engineers, plant managers, and engineering executives.

ROTOJET Water-driven Motor Model 321 with short 4-arm head and universal joint for 2½"-3" I.D. curved tubes.

The New ROTOJET Water-driven TUBE CLEANER

Cleans tubes 2½ TIMES FASTER in a New Jersey power plant

The best previous cleaning time with ordinary water-driven tube cleaners in these boilers with 3" curved tubes ranged from 10 to 20 minutes, depending upon scale conditions. ROTOJET Model 321 reduced the time per tube to 4 minutes. While previous tube cleaners used water pressures of 150-200 psi, ROTOJET established its record on only 100 psi. At 125-150 psi recommended pressure ROTOJET would have done ever better.

Considering the time, labor, and water ROTOJET saves, it should repay its entire purchase price the first time you use it. Send for new bulletin.

ELLIOTT COMPANY-ROTO DIVISION

160 Sussex Avenue Newark 1, N. J.

SEE HOW YOU CAN CUT POWER COSTS AT THE...

18th NATIONAL POWER SHOW

NATIONAL EXPOSITION OF POWER & MECHANICAL ENGINEERING

GRAND CENTRAL PALACE, N.Y.

NOV. 29 to DEC. 4

Over 300 outstanding technically-staffed exhibits and first-hand demonstrations of latest cost-saving equipment, materials and methods for steam, electric and mechanical power production and application—for economical materials handling — for efficient plant services — for expanding and modernizing power facilities. New cost-cutting ideas never were so important as now. So mark the date—plan to attend. See, learn and compare!

Management International Exposition Co.

4545

Record Turbine-Generator Output

General Electric's Schenectady turbine plant during the first six months of 1948 produced turbine-generators with a combined kilowatt capacity greater than that of all the units manufactured at the plant in 1947, a high production year.

In the half-year period ending June 30, thirty units representing 1,237,500 kw were built and tested. Some of these already have been installed by utilities and others soon will be. Thirty-four turbine sets with a total capacity of 1,173,750 kw were shipped out of Schenectady last year.

Based on this record half-year performance, it is predicted that the plant would turn out more than 1,500,000 kw of turbine-generators during the last six months of 1948.

The company's production of turbine-generators for power plants by the end of 1948 is expected to reach 2,800,000 kw which will exceed by more than 1,000,000 kw the figure for any previous year in the Schenectady plant's history.

Production of lower-rated turbine-generator units at the company's Lynn (River Works), Mass., plant also is continuing at an accelerated pace. Units totaling 268,250 kw were built and shipped during the first six months of 1948.

Post-War Power Expansion in Belgium

Post-war expansion of power facilities in Belgium is indicated by a list of Brown Boveri steam turbines recently installed on an order for extensions to twelve power stations. As listed in the last issue of the *Brown Boveri Review*, sixteen turbine-generators, ranging in capacity from 12,000 to 50,000 kw and totaling 535,000 kw are involved. Included are two 50,000-kw units for the Schelle Station which supplies a considerable amount of power to the industrial area in and around Antwerp.

The foregoing represents orders from a single manufacturer of turbines. Others have undoubtedly been placed with other turbine builders. In fact, a number of large steam-generating units are now on order with American firms to meet this expansion program.

Howard Butt Passes

Howart Butt, Vice-President and Manager of the New York Office of The Wm. Powell Company, died at his home in Morristown, N. J., on August 23, in his 58th year. After attending Alabama Polytechnic Institute, Mr. Butt became associated, in sales, engineering and managerial capacities with several large engineering organizations. In 1930 he joined The Wm. Powell Company, valve manufacturers of Cincinnati, Ohio, and was made a vice-president in 1944. He was widely known in engineering circles, holding memberships in the Engineers' Club of New York, the Economic Club, A.S.M.E., Spring Brook Country Club (Morristown), and Sky Top Lodge (Pennsylvania).

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Thermodynamics First Edition

By Edward F. Obert

Many textbooks have been written on the subject of thermodynamics, but this one has been made more complete than the average with a view to extending the coverage beyond the usual undergraduate requirements, without, however, in any way sacrificing the fundamentals. The author, who is associate professor of mechanical engineering at Northwestern Technological Institute, Northwestern University, points out that this was done to encourage the student to progress beyond the borders prescribed by the instructor.

Many of the chapters have been developed as separate entities, of which that on "power cycles" is particularly good. These chapters deal with dimensions and units, fundamental concepts, the first law of thermodynamics, the reversible process, the second law of thermodynamics, properties of fluids, characteristics of gases, approximate calculations for real gases, flow of fluids, mixtures of gases and vapors, thermochemical calculations, power cycles (both vapor and gas) and refrigeration. While including fundamentals pertaining to heat-power engineering, the author explains that it was not the intention to have this book supplant a textbook on heat power, although in his opinion no justification exists for separate courses in thermodynamics and heat power.

Despite the employment of considerable mathematics in places, the explanations are clear and the sketches are both simple and well chosen. In fact, most of the text should be readily comprehended by the average practicing engineer, even though he may be a bit rusty in his thermodynamics.

An extensive appendix contains numerous tables, curves and charts.

There are 571 pages, adequately illustrated, bound in cloth and priced at $5.50.

Molybdenum: Steels, Irons and Alloys

By R. S. Archer, J. Z. Briggs and C. M. Loeb, Jr.

This 391-page book just issued by Climax Molybdenum Company describes various applications of molybdenum as an alloying element with a wide range of materials.

The scope of the book is indicated by the following section headings: technical effects of molybdenum, fundamental effects of heat treatment on microstructure, addition of molybdenum by various processes, wrought alloy engineering steels, wrought corrosion-resistant steels, wrought steels for elevated temperature service, tool steels, steel castings, cast iron, and special purpose and nonferrous alloys

An attempt has been made to show the fields of similarity and dissimilarity of the various materials and to indicate some of the factors that may affect the choice of the most economical material for a specific purpose. Considerable space is devoted to a compilation of hard-to-find information on specialty applications and the Appendices include data on standard American, British and French engineering steels, working stresses from the A.S.M.E Boiler Code, as well as the physical properties of metallic molybdenum.

The book is being distributed free of charge by Climax Molybdenum Company, 500 Fifth Ave., New York 18, N. Y., to metallurgists and other qualified individuals associated with the metallurgical work.

Standards on Coal and Coke

Some 29 standard specifications and tests covering coal and coke, as issued by the A.S.T.M., are published in a special compilation of 163 pages. They are as of September, 1948, and incorporate changes made during the current year, plus new material.

Test methods and procedures pertaining to coal cover, sampling, analysis for volatile in connection with smoke ordinances, grindability, drop shatter test, tumbler test, screen analysis, size, sieve analysis, cubic foot weight, index of dustiness, and free-swelling. Specifications cover classification by rank and grade.

For coke there are methods for sampling, and tests for volume of cell space, drop shatter, tumbler, sieve analysis, and cubic foot weight. Included are a number of definitions.

An Appendix contains proposed methods which the Committee is now studying involving: test for expansion pressure of coal during coking; test for plastic properties of coal by the Davis plastometer; test for plastic properties of coal by the Gieseler plastometer; test for carbonization pressure of bituminous coal; measurement of pressures developed during carbonization by the movable wall oven; expansion properties of coal for use in by-product coke ovens; test for pressures, strains, and other properties developed during carbonization; and test for agglutinating value. The booklet, bound in a heavy paper cover, is priced at $2.

Personals

Prof. A. G. Christie, for the past 35 yr professor of mechanical engineering at Johns Hopkins University, has retired and will devote much of his time to consulting work in the power plant field. He is a past-president of the A.S.M.E. and has been an occasional contributor to COMBUSTION.

Gordon R. Milne has been appointed mechanical engineer of the Consolidated Edison Co. of New York, to succeed E. B. Ricketts, recently retired. Mr. Milne has held various positions with the Company, or its affiliates, for the past 27 yr.

B. C. Mallory has been named chief mechanical engineer of Stone & Webster Engineering Corp., succeeding the late James A. Powell.

William G. Christy, smoke abatement engineer of Hudson County, N. J., was recently elected president of the Smoke Prevention Association of America.

Business Notes

G. L. Harman, Jr., has been appointed manager of the Milwaukee Office of the **Bailey Meter Co.** He had previously been attached to the Company's Los Angeles branch.

Thomas G. Gleason has been added to the New York Office staff of **Peabody Engineering Corp.** He will be engaged in studying special applications and in development work of the Scrubber Div.

T. J. Hodan has been named manager of the Water Conditioning Dept. of the **Allis-Chalmers Co.,** Milwaukee. He succeeds W. L. Manly who has become manager of dealer sales.

C. F. McGinnis has been appointed assistant sales manager of the Ridgway Div. of **Elliott Co.,** Jeanette, Pa.

A. W. Lenderoth has been named special representative of the **J. E. Lonergan Co.** in connection with safety valve, relief valve and pressure gage requirements, with headquarters at 30 Church St., New York.

T. N. Rimback has joined **Liquid Conditioning Corp.** of Linden, N. J., as district manager of the territory comprising the states of Missouri and Arkansas, the eastern part of Kansas and the southern part of Illinois.

Two additional representatives have been announced by **L. J. Wing Mfg. Co.** for the sale of heating, ventilating and combustion equipment in Canada. They are J. C. Davis Ltd. of Winnipeg, which will cover Manitoba, Saskatchewan and Alberta, and the Control Equipment Co. of Toronto for the Ontario territory. Preston Phipps of Montreal will continue representation in the province of Quebec.

A. Kolstad of Kolstad Engineering & Sales Co., Long Beach, Calif., has been appointed sales representative of **Thomas C. Wilson, Inc.,** manufacturers of tube-cleaning equipment.

The company your boiler keeps . . .

APEXIORIZED

New boilers APEXIORized during the past year alone are serving these industries:

CHEMICALS	MACHINERY
FOODS	PUBLISHING
PETROLEUM	UTILITIES
BREWERIES	GOVERNMENT
TEXTILES	INSTITUTIONS
PAPER	MINING

Pick any industry where steam is generated for power or process and you've named a representative group of APEXIOR users — engineers who have proved the worth, in boilers large and small, of internal protective surfacing.

They know that even the strongest steel is powerless to resist moisture penetration — that water at its finest retains the capacity to impair — can never improve — bare steel. And so they separate the two, sealing boiler metal beneath a tissue-thin barrier of APEXIOR NUMBER 1.

Meeting steam and water is a surface that neither can dissolve — smooth, to deny a foothold to deposits — inert, so that it forms only a readily broken mechanical bond with any that adhere. The result, for the legion of APEXIOR users — —

- *maximum boiler availability — security against corrosion*
- *improved circulation, through friction-free tubes*
- *constant high heat-transfer efficiency*
- *easier, less frequent cleaning — lower maintenance cost*
- *speedier, positive inspection*
- *less outage time — longer on-the-line service*

Write us for more facts about:

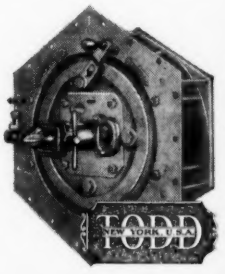
DAMPNEY maintenance for metal

THE DAMPNEY COMPANY of AMERICA • Hyde Park, Boston 36, Mass.

THERE'S STILL TIME TO MODERNIZE YOUR BOILER PLANT WITH TODD BURNERS

You *can* replace obsolete equipment with Todd Burners and be ready for winter. The capacity of the Todd organization . . . world-wide distributors and facilities . . . standardized equipment . . . are your assurance of economy and efficiency in the burning of liquid and gaseous fuels. Take advantage of the long experience and "know how" of Todd engineers.

Oil Burners
Gas Burners
Combination Oil and Gas Burners



COMBUSTION EQUIPMENT DIVISION
TODD SHIPYARDS CORPORATION
81-16 45th Ave., Elmhurst, Queens, N. Y.

NEW YORK • BROOKLYN • ROCHESTER
BUFFALO • HOBOKEN • NEWARK • PHILADELPHIA
HARRISBURG • YORK • CHICAGO • CHARLESTON, S. C. • BOSTON • SPRINGFIELD, MASS.
BALTIMORE • WASHINGTON • RICHMOND, VA.
ATLANTA • DETROIT • GRAND RAPIDS • TAMPA
GALVESTON • HOUSTON • MOBILE • NEW ORLEANS • LOS ANGELES • SAN FRANCISCO
SEATTLE • MONTREAL • TORONTO
BARRANQUILLA • BUENOS AIRES • LONDON